A STUDY OF WATERFOWL ECOLOGY ON SMALL IMPOUNDMENTS
IN SOUTHEASTERN ALBERTA

BY

LLOYD BURROWS KEITH

A thesis submitted in partial fulfillment of the
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A STUDY OF WATERFOWL ECOLOGY ON SMALL IMPOUNDMENTS IN SOUTHEASTERN ALBERTA

A thesis submitted to the Graduate School of the University of Wisconsin in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

by

Lloyd Burrows Keith

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To Professors: McCabe

Todd

Hickey

This thesis having been approved in respect to form and mechanical execution is referred to you for judgment upon its substantial merit.

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Approved as satisfying in substance t... doctoral thesis requirement of the University of Wisconsin.

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Date of Examination, May 1 1959

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INTRODUCTION

The object of this paper is to present information on waterfowl ecology and populations, derived from studies conducted over five breeding seasons on a group of small impoundments in southeastern Alberta.

The parklands and mixed-prairie grasslands of the three Prairie Provinces extend almost 800 mi. east and west, and up to 400 mi. north and south. This region is the acknowledged "duck factory" of North America. The parklands, an ecotone between grassland and boreal forest, comprise about 85,000 sq. mi. The many natural lakes and potholes here are seldom dry. On the other hand, grassland areas totalling approximately 100,000 sq. mi. contain numerous drought-susceptible water areas. These shallow ponds may vanis[illegible]y through the breeding season in years of low rainfall and/or poor runoff, and during such times tens of thousands of young waterfowl undoubtedly perish.

Two organizations are actively engaged in construction of permanent impoundments on the mixed prairie. The Dominion Government sponsored Prairie Farm Rehabilitation Act (P.F.R.A.) is chiefly interested in developing stock ponds and dugouts for agricultural purposes, while Ducks Unlimited (Can.) is endeavoring to create stable breeding habitat for waterfowl. Frequently, impoundments built by Ducks Unlimited also serve ranchers and farmers, and P.F.R.A. waters, of course, often raise ducks.

Ducks Unlimited's projects on the mixed prairie fall into two major categories, viz. those depending wholly on runoff, and those receiving waste or surplus irrigation water. The present study was undertaken on one of the latter type. This project furnished an opportunity to compare waterfowl usage of several kinds of impoundments, and to conduct a limited number of water-level manipulations. The study was initiated as a broad ecological investigation of waterfowl. Findings are presented and discussed under seven major headings: (1) The study-area region, (2) Vegetation and soils of the study area, (3) Food habits, (4) Breeding population, (5) Nesting, (6) Productivity, (7) Management.

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Bill Wishart, Don Grace, and Kent Klepinger were field assistants in 1954, 1956, and 1957 respectively. I am heavily indebted to each for much hard work under frequently trying conditions.

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THE STUDY-AREA REGION

Description and History of Study-Area Region

The plains of southeastern Alberta, due to their climatic vagaries, were alternately described as part of the "central arid desert" and as the "garden of the whole country" in reports of early explorers (Roe, 1946).

Ranches were first established here on completion of the Canadian Pacific Railroad in 1885. Rangeland subsequently yielded to grain farms when large numbers of homesteaders arrived between 1909 and 1916 (Wyatt *et al.*, 1937). Later, recurrent dry years forced widespread abandonment of these lands. Irrigation districts, constructed about 1910-20, absorbed some families, while others moved northward into the parkland and forested zones.

Climate—The climate of this region is typical of the Norther Plains. Normal variation in temperature and rainfall, both within and between years, is extreme. For example, 35 mi. east-southeast of the study area, at Jenner, the average yearly high temperature is 100°F. and the average yearly low is -42°F. (Dept. of Transport, *n.d.*). Precipitation at Jenner, Brooks (Fig. 1) and Medicine Hat averaged 21.89 in. during 1927 and only 9.64 in. during 1928 (Wyatt *et al.*, 1937).

Average January and July minimum temperatures at the three nearest weather stations are -2°F. and 52°F. respectively (Table 1). The average daily maximum in July is 82°F. Snowfall is light, amounting to less than 40 in. a year. Mean annual precipitation totals 12.86 in., of which 41 percent occurs in May, June, and July.

TABLE 1.--AVERAGE OF MEAN MONTHLY CLIMATIC DATA FROM BASSANO, BROOKS, AND JENNER, ALBERTA 1/

Month	Min. Temp. (°F.)	Max. Temp. (°F.)	Precip. (in.) 2/	Snowfall (in.) 2/
January	-2	20	0.64	6.0
February	3	26	0.52	5.0
March	14	37	0.60	5.6
April	29	54	1.13	3.9
May	39	66	1.86	1.2
June	48	74	1.69	tr.
July	52	82	1.74	
August	49	79	1.27	
September	38	67	1.29	0.5
October	29	55	0.64	2.3
November	15	37	0.65	5.8
December	4	24	0.83	8.2

1/ For 20 years at Jenner and Bassano, and for 23 years at Brooks.

2/ Bassano and Jenner only, data not available for Brooks.

Evaporation-precipitation ratios are in the vicinity of 2:1 (Clarke and Tisdale, 1936). Winds are predominately westerly and include the desiccating chinooks. Relative humidity is low, 11:30 a.m. determinations at Medicine Hat ranging from an average of 77 percent in January to 45 percent in July (Dept. of Transport, 1948). The mean frost-free period each year is approximately 110 days (Dept. of Transport, 1956).

Natural Vegetation--Several grassland communities, collectively termed "mixed prairie," form the natural vegetation. Six dominant grasses are listed by Coupland (1950): Stipa comata, S. spartea var. curtiseta, Bouteloua gracilis, Agropyron smithii, A. dasystachyum, and Koeleria cristata. Chief dicot families are the Compositae and the Leguminosae; Rosa spp. and Symphoricarpos occidentalis are common shrubs. Trees are confined to permanent watercourses and north-facing slopes of coulees.

Geology and Soils—Bedrock consists of Upper Cretaceous sediments; these sandstones and shales are usually overlaid by unconsolidated glacial deposits. In the study area's proximity, there has been extensive alluvial and aeolian resorting of the thick morainal covering (Allen, 1937). Glacial drift, the soil's parent material, is a mixture of Pre-Cambrian rock from the Hudson Bay region and sandstone and shales from the underlying strata (Wyatt et al., 1937).

Soils belong to the Brown Soil Group, and are low in organic matter and nitrogen but fairly well supplied with minerals. They have evolved under relatively arid conditions from calcareous parent materials; as a result, a prominent lime layer is often seen between 9 and 24 in. (Wyatt _et al._, 1937).

Agriculture--Agricultural activities in this section of Alberta fall into the three major categories of ranching, dry-land grain farming and irrigation farming.

The carrying capacity of rangeland is about 20-25 ac. per cow per year. Native grasses are highly nutritious and usually cure on the stand, thus making fall and winter grazing possible (Clarke, 1930).

Dry-land farms produce hard spring wheat, fall rye and flax. Soil moisture is the limiting factor in cereal-crop production, and summer fallowing is practiced every second or third year to build up a water reserve. Simple grain-fallow rotations are commonly followed.

On irrigated lands, farming is more diversified; [illegible]s and barley become important grain crops, and large acreages are [illegible] [illegible]lfalfa hay. Most irrigated farms raise both livestock and grain. In the Eastern Irrigation District of southeastern Alberta, an absence of suitable processing facilities (Dunsmore, 1950) has prevented the growing of specialty crops (sugar beets, canning corn, etc.).

The Eastern Irrigation District--The Eastern Irrigation District (E.I.D.) encompasses the largest irrigation project in Canada. It contains 1.5 million ac., 160,000 ac. of which were under water contract to 1,500 farmers in 1948. Another 120,000 ac. are potentially irrigable (Dunsmore, 1950).

This irrigation scheme was built by the Canadian Pacific Railroad as a means of increasing its revenues. In 1914, a dam to provide water was completed on the Bow River near Bassano (Fig. 1).

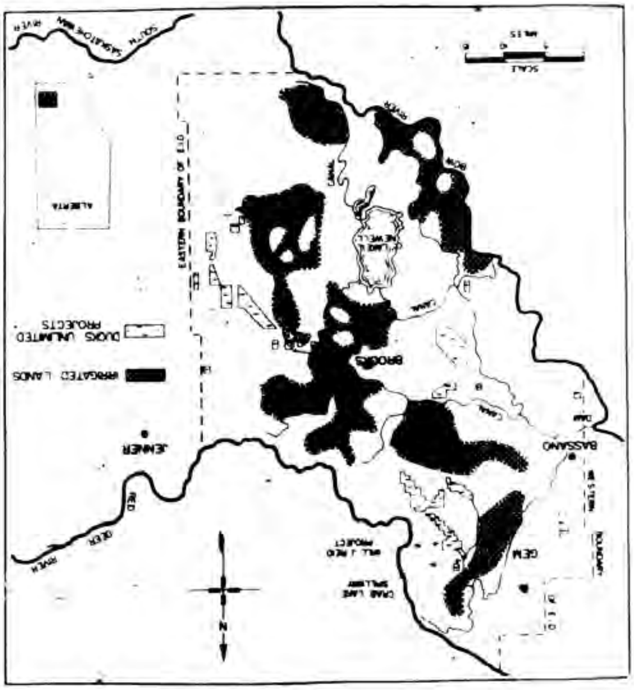

Fig. 1. The Eastern Irrigation District of southeastern Alberta, showing distribution of irrigated lands (after Dunsmore, 1950) and Ducks Unlimited projects.

A large storage reservoir (Lake Newell) was also created south of Brooks. Irrigating was first begun in the summer of 1917 (Wyatt et al., 1937).

The cost of development was \$47.00 per irrigable acre; land was sold to settlers at \$50.00 per irrigable acre, and \$10.00 per acre of dry land. The economics of this venture were discussed by Dunsmore (1950) who stated: "Such prices proved to be considerably higher than returns from the land would justify and after many years of deficit operation the railway paid the farmers of the area a substantial sum to take the project off their hands. No return was ever realized on capital invested in the original development of the area."

In 1935, under the Irrigation Districts Act (Alberta), the Eastern Irrigation District was formed. The Canadian Pacific Railroad turned the entire area, including all irrigation works a[illegible]es, over to the farmers. The E.I.D. was thereafter run by a board of five trustees elected by district ratepayers, and the costs of operation met by an annual water charge (1958 water rate was \$2.25 per irrigable acre).

Topography and soil types divide irrigable land within the E.I.D. into eight blocks, often separated by large tracts of grassland. These are leased to ranchers, or to local groups for community pastures. Grassland areas have also been utilized by Ducks Unlimited as project sites (Fig. 1). At present there are 24 Ducks Unlimited projects in the E.I.D., comprising almost 8,000 ac. of water.

The Will J. Reid Project--The Will J. Reid project was the site of the present study. In 1944, representatives of two grazing interests--the

Rosemary Grazing Association and Stringham Brothers--contacted Ducks Unlimited with regard to establishing permanent water on lands leased by them from the E.I.D. They pointed out that the scarcity of natural waterholes made it difficult to graze these holdings effectively.

Ducks Unlimited completed surveys early in 1945 and approved a project to be named in honor of W. J. Reid, a past president of Ducks Unlimited (Inc.). The land had been ditched for irrigation between 1910 and 1914 but, due to its sandy texture and the danger of alkali development, had never been farmed. Although the original ditches were in generally poor condition, it was deemed easier to repair some of these than to construct new ones. Surplus irrigation water would be diverted from Crab Lake spillway (Fig. 1) and impounded in a series of small lakes and potholes.

In the summer of 1945, at Ducks Unlimited's expense, temporary diversion works were installed on Crab Lake spillway by farm labor; and sufficient excavation of an old ditch was completed to move water about 4 mi. into the lease. Ducks Unlimited finished the project during 1946; construction details are summarized below:

1. Built eight earth dams and four dykes with a total yardage of 17,900 cu. yd.

2. Cleaned out and ran to grade 9,400 ft. of old service ditch.

3. Excavated 9,800 ft. of new service ditch.

4. Installed one 5-ft.-diameter culvert weir and drop.

5. Installed two 12-in. and one 30-in. culvert controls and three timber controls.

6. Installed five timber-drop and five standard culvert-drop structures.

7. Constructed two timber bridges and one culvert crossing.

8. Made 6.1 mi. of scraper trail.

In the fall of 1947, 1.5 mi. of fence was erected around a group of potholes. Spring runoff in 1948 destroyed the earth and timber diversion dam on Crab Lake spillway, and a new concrete check-and-drop structure was built that summer. Construction costs of the Will J. Reid project and a southern extension known as the Solano project totalled $38,679; maintenance costs, including administrative overhead and repairs, between 1947 and 1958 amounted to $2,538 (Angus Gavin, <u>in litt.</u>).

<u>Impoundments of the Study Area</u>

<u>General Layout and Water Control</u>--The impoundments of the study area (Figs. 2, 3) are situated entirely on grazing land. They lie in what appears to be a natural drainage way, bounded on the west by a low moraine, on the south and east by partly stabilized sand dunes, and on the north by gently rolling prairie.

When stop logs are placed in the check-and-drop structure on Crab Lake spillway, water is backed up and enters the ditch supplying the Will J. Reid project. It flows for 3 mi. and passes through two timber controls before reaching the study area. Water may leave D-area Lake (Fig. 2) by two routes, viz. down an overflow pipe (Fig. 4) into A-area Potholes, or through a culvert control into B-area Potholes. The overflow fixes the maximum level of this lake, and the culvert permits a draw-down of about 12 in. At the lower end of A-area, water

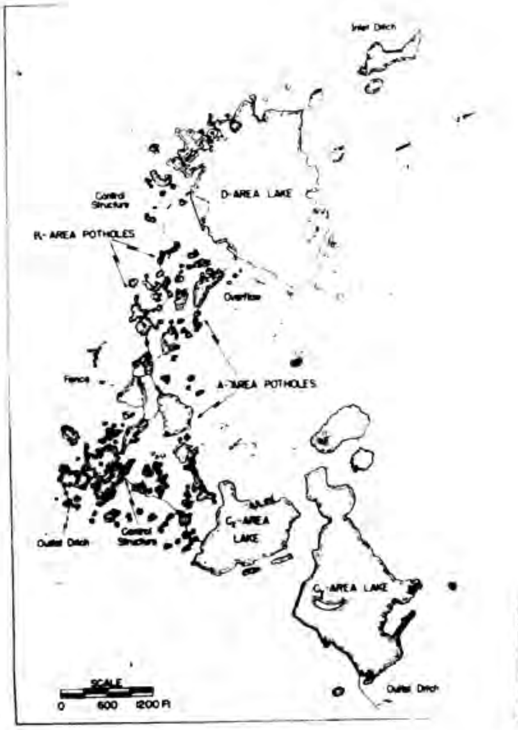

Fig. 2. Impoundments on the study area.

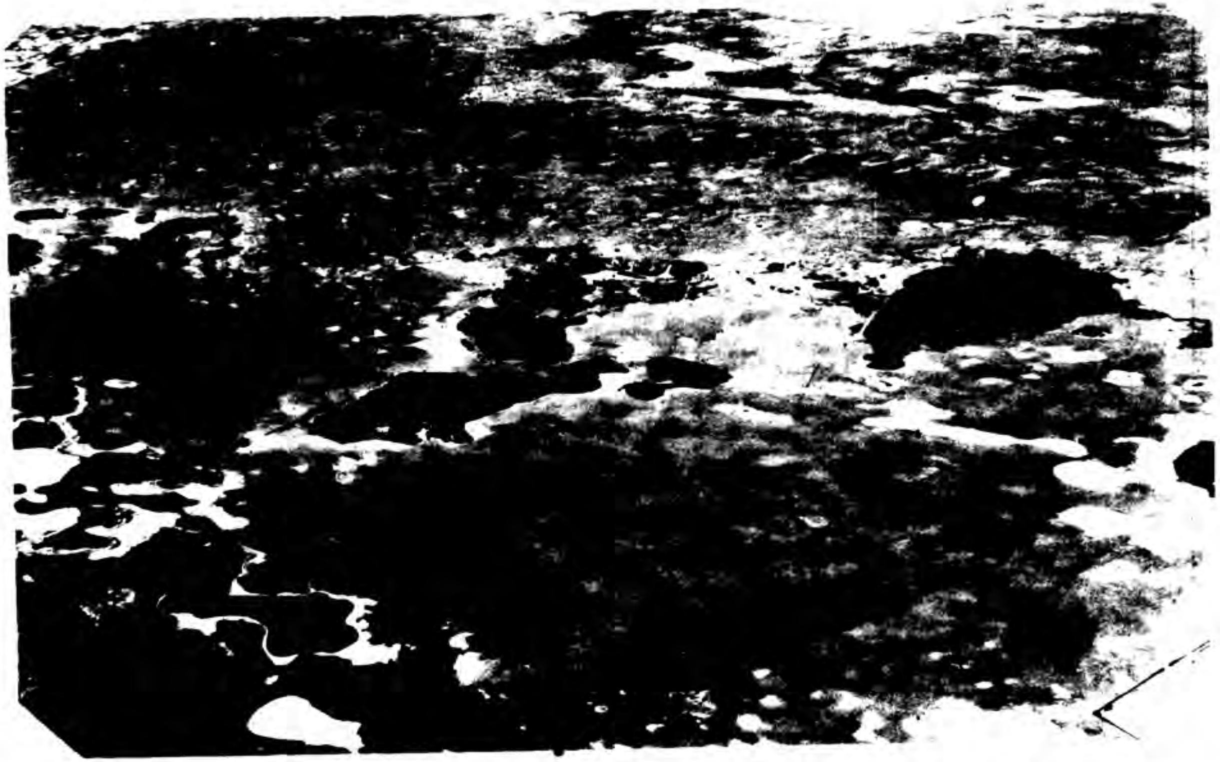

Fig. 3. Aerial photo of the study area and nearby impoundments, taken from the northeast (Ducks Unlimited photograph).

Fig. 4. Overflow structure on D-area Lake.

flows either towards another Ducks Unli ted scheme 1 mi. south, or is diverted into Cz- and Cy-area Lakes.

Seasonal Availability and Loss of Water--This project depends upon surplus irrigation water. The date at which water is first available, and the amount that can be had, is governed largely by two factors: (1) the time when irrigating begins in the Gem district, and (2) the quantity utilized by farmers. The latter directly affects the amount that is surplus or spill.

Because the above factors vary from year to year, the study area's water supply during spring and summer is neither constant nor predictable. In fall, the main irrigation canals are "flushed out," and there is always ample water to fill the impoundments at that time. Frequently, enough spring runoff enters Crab Lake spillway to allow diversion of a limited stream. Between 1953 and 1958, surplus irrigation water was first obtainable as follows: 1953--July 17, 1954--June 4, 1955--June 9, 1956--May 29, 1957--May 25, 1958--May 24. Fortunately, conditions that tend to lower water levels, i.e. high temperatures, dry winds and low rainfall, likewise tend to initiate irrigation. Thus, some spill is available well in advance of any serious water loss.

Spring and summer declines in water levels, through evaporation and seepage, averaged 0.23 in. per day in lakes, and 0.35 in. per day in potholes (Table 2). What percentage is attributable to evaporation and what percentage to seepage is not known. The higher rate of water loss from potholes might result from increased evaporation caused by their more rapid warming, and/or from proportionately greater transpiration by emergent and shoreline vegetation. On the average, lake

TABLE 2.—SUMMARY OF WATER-LEVEL DECLINES ON STUDY AREA DURING PERIODS OF NEGLIGIBLE RAINFALL 1/

Area	Period (days)	Total Decline (in.)	Av. Decline Per Day (in.)	Av. Daily Max. Temp. (°F.)
D-area Lake	50	13.00	0.26	81
Cz-area Lake	28	6.50	0.23	71
Cy-area Lake	37	7.50	0.20	75
Totals and means	115	27.00	0.23	76
A-area Potholes	97	33.75	0.35	76
B-area Potholes	65	23.00	0.35	76
Totals and means	162	56.75	0.35	76

1/ No inflow or outflow of water through ditches.

levels rose 2.0 in. per inch of rainfall, while pothole levels rose 2.4 in. (Table 3).

Data on the rate of water loss and the effect of rainfall enable one to estimate water-level declines during a "normal" summer. The May-September water loss in lakes comparable to those on the study area (21-71 ac.) would be about 1.5 ft., and potholes would drop about 3 ft. Levels could easily fall one and one-half to two times as much in drought years. These figures have practical application when planning groups of drought-safe impoundments in terms of available water supply.

Subdivisions of the Study Area

The study area, a rectangular block totalling roughly 680 ac., at first contained four distinct kinds of impoundments. These are designated in Fig. 2 as D-area Lake, Cy-and Cz-area Lake [illegible]-area Potholes, and B-area Potholes. The letters assigned to impoundments have no particular significance but were simply given to each at the inception of the study.

Water-level fluctuations and the occurrence of mudflat conditions on each subdivision of the study area are outlined in Figs. A to E (Appendix). Water gauges were read weekly or oftener. Mudflat conditions were defined as an average of at least 18 in. of bare mud or sand exposed beyond the usual shoreline or encroaching moist-soil vegetation; by and large they were much more extensive. Because mudflats were soon invaded by new plant growth, water levels producing mudflats on a particular impoundment were not always constant from

TABLE 3.—EFFECT OF RAINFALL ON WATER-LEVEL DECLINES ON STUDY AREA 1/

	Lakes	Potholes
Period (days)	235	175
Av. decline per day (in.)	0.13	0.23
Av. rainfall per day (in.)	0.05	0.05
Av. gain in water level due to rainfall 2/	0.10 (0.23-0.13)	0.12 (0.35-0.23)
Gain in water level (in.) per in. of rainfall	2.0 (0.10/0.05)	2.4 (0.12/0.05)

1/ No inflow or outflow of spillwater through ditches.
2/ Av. decline with no rainfall (Table 2) minus av. decline with rainfall.

year to year, or indeed even from month to month. Changes taking place in vegetation, salinity, etc. are summarized in Tables A to E (Appendix). The significance of some of these changes is discussed more fully in later chapters.

D-area Lake—The maximum size of this lake is 71.4 ac. Its average depth is just over 3 ft., and its deepest point is 8 ft. Total shoreline length equals 3,600 yd., about one-quarter of this consisting of dam side. There are six islands in the lake, the largest being 0.5 ac. The salt content of the water—of importance to aquatic plant growth—averages around 200 p.p.m.

Submergent vegetation includes seven species of pondweeds (Potamogeton spp.), water milfoil (Myriophyllum exalbescens), coontail (Ceratophyllum demersum), water-weed (Anacharis canadensis) and muskgrass (Chara sp.). Cattail (Typha latifolia) is restricted to ungrazed islands. Scattered stands of softstem bulrush (Scirpus validus) dot the center of this lake. Shoreline vegetation (Fig. 5) is dominated by Juncus balticus, sedges (mainly Carex praegracilis), spike-rush (Eleocharis palustris) and Lycopus asper. The surrounding uplands and shorelines are grazed by cattle. Five of the islands are usually inaccessible to livestock.

Cy- and Cz-area Lakes—At the outset of investigations in 1953, both lakes had extensive saline mudflats and were considered as a single habitat type. That fall, the level of Cz-area Lake was raised 2 ft., submerging the mudflats and markedly altering the shoreline vegetation. Henceforth, it was necessary to evaluate Cy- and Cz-area Lakes separately.

Fig. 5. Shoreline vegetation of D-area Lake, largely <u>Juncus balticus</u>; cattail-fringed islands in background.

Cy-area Lake has a maximum si: of 48.4 ac. and a shoreline length of 3,600 yd. Its average and greatest depths are 4.5 ft. and 8 ft. respectively. This lake has one island. S linity is known to have attained 1,044 p.p.m. in 1956, and is thought to have been even higher during 1953 and 1954 when water levels were much lower.

The chief submergent species is water milfoil; pondweeds are much scarcer than in D-area Lake and there is no water-weed or coontail. Cattail and softstem bulrush are absent, however, limited stands of alkali bulrush (*Scirpus paludosus*) occur here. Various halophytes are common along the shoreline (Fig. 6).

Cz-area Lake is 20.8 ac. and has a 1,200-yd. shoreline. The average depth is 3-3.5 ft., and the maximum depth is 5 ft. With higher water levels in the fall of 1953, the salinity of Cz-area Lake evidently dropped. During July 1956, it contained 320 p.p.m. dissolved

Submergent vegetation, as shown later, resembles that in D-area Lake. Incipient stands of cattail and softstem bulrush have appeared from time to time but failed to persist. Shorelines consist mainly of *Juncus balticus*, *Hordeum jubatum* and spike-rush. Cattle graze both Cy- and Cz-areas.

A-area Potholes--There are 20.4 ac. of water in potholes of A-area. The largest is 4.2 ac.; 5 others are over 1 ac., 3 are between 0.5 and 1 ac., and 40 are still smaller in size. Mean depths range from 3 ft. to less than 1 ft., and the deepest is 5.5 ft. Shorelines total approximately 5,900 yd. The salt content of these waters averages 200 p.p.m.

Fig. 6. Shoreline of Cy-area Lake with saltgrass and alkali bulrush encroaching on saline mudflats.

Water milfoil, coontail, mus' rass and Potamogeton pusillus are the leading submergents. Eighty-seven percent of the shorelines are cattail-bordered (Fig. 7), and the remaining 13 percent are composed of Juncus balticus and sedges. This area is fenced and thus has been subjected only to sporadic grazing.

B-area Potholes--B-area Potholes are twelve in number and small, having an entire surface area of just 3.6 ac. One pothole is 1.2 ac. and the rest are less than 0.5 ac. Average depths do not exceed 2 ft. The maximum depth of the largest pothole is 4.5 ft. There are 2,200 yd. of shoreline, part of which is saline mudflat. The salinity of different potholes varies greatly, with extremes of 2,285 p.p.m. and 288 p.p.m. recorded. These differences exist because water flows directly through some, while others depend largely on runoff and ground water.

The most common aquatics are water milfoil, Potamogeton pusillus, mare's tail (Hippuris vulgaris), and muskgrass. Spike-rush and three-square bulrush (Scirpus americanus) are abundant in shallow water and on moist soils. Juncus balticus and sedges are the principal shoreline species (Fig. 8). The entire area is grazed.

Fig. 7 A cattail-bordered pothole in A-area.

Fig. 8. A pothole in B-area; darker band of vegetation is mainly Juncus balticus.

Summary

The climate of this region is characterized by extreme seasonal and yearly variations in temperature and rainfall. Mean annual precipitation is only 12.86 in., 41 percent of which falls in May, June, and July. Natural vegetation is mixed prairie, and soils belong to the Brown Soil Group. The principal agricultural activities are ranching, dry-land grain farming, and irrigation farming. The Eastern Irrigation District in southeastern Alberta is the largest irrigation scheme in Canada. Ducks Unlimited has been able to utilize surplus irrigation water to develop projects in this region. The Will J. Reid project, a Ducks Unlimited undertaking completed in 1946, was the site of the present study.

Study-area impoundments are situated on grazing land. Water is diverted from a spillway 3 mi. distant, and usually becomes available when irrigating begins. Evaporation and seepage accounted for an average daily decline of 0.35 in. in potholes and 0.23 in. in lakes. Lakes rose 2.0 in. per inch of rainfall, while potholes rose 2.4 in. The net decline in water levels during a "normal" May-September period was calculated at about 1.5 ft. in lakes and 3 ft. in potholes. The five subdivisions into which the study area was divided are described.

VEGETATION AND SOILS OF THE STUDY AREA

During the present study, terrestrial and aquatic vegetation were investigated and the primary cover types mapped (Fig. 9). Most terrestrial vegetation was arbitrarily grouped into three major plant communities—mixed prairie, Juncus, and halophytic—differing in species composition, general physiognomy and edaphic requirements.

A complete list of all plant species that were collected and identified is given in the Appendix, together with methods employed in sampling and in soil and water analyses.

Mixed-Prairie Community

The mixed-prairie community (Table 4) most nearly resembled Coupland's (1950) Bouteloua-Stipa fasciation, which he described having Bouteloua gracilis and Stipa comata as dominants, with Koeleria cristata, Agropyron smithii, A. dasystachyum, Stipa spartea var. curtiseta, Carex eleocharis and C. filifolia as other principal species.

The soil's texture and heavy grazing by horses and sheep were probably responsible for differences between the study area's mixed-prairie community and the typical Bouteloua-Stipa fasciation mentioned above. Calamovilfa longifolia, a grass of sandy areas, was one of the leading species. According to Clarke (1930) its high silica content makes Calamovilfa harsh and comparatively unpalatable to livestock except in winter and early spring. This fact may have accounted for the limited grazing to which it was subjected during the July-November period when cattle were present in numbers on the study area. Serious

Fig. 9. Map of study area showing distribution of the four primary cover types.

TABLE 4.--SPECIES COMPOSITION OF THE MIXED-PRAIRIE COMMUNITY ON STUDY AREA FROM TWO SETS OF QUADRAT DATA 1/

Species	Percentage Total Length of Vegetation	Percentage Frequency	
	32 Quadrats--May-August 1953-54	32 Quadrats--May-August 1953-54	60 Quadrats--mid-July 1956
GRASSES AND SEDGES			
Calamovilfa longifolia	12.6	81	66
Bouteloua gracilis	30.7	91	78
Stipa comata	17.2	100	72
Agropyron smithii	3.0	41	35
Koeleria cristata	8.1	63	22
Agrostis scabra	0.2	6	20
Poa secunda			3
Hordeum jubatum	tr.	3	
Carex spp. 2/	24.2	100	100
FORBS			
Artemisia frigida	1.4	63	[illegible]
Thermopsis rhombifolia	0.4	9	[illegible]
Vicia trifida	0.1	13	20
Artemisia gnaphalodes	0.8	31	12
Chrysopsis villosa	tr.	3	12
Taraxacum officinale			8
Glycyrrhiza lepidota	0.2	6	2
Antennaria microphylla	--		2
Epilobium lineare	tr.	3	
Unidentified spp.	0.2	22	3
SHRUBS			
Rosa sp.	tr.	3	
OTHERS			
Equisetum sp.	0.9	13	15
Juncus balticus			5
Opuntia sp.	tr.	3	2

1/ See Appendix for sampling methods.
2/ Mainly Carex heliophila, C. douglasii, C. eleocharis.

overgrazing occurred here prior to 19 and is currently manifested through such indicators as Artemisia spp. and Thermopsis rhombifolia. Grazing has likely provoked increases in Bouteloua gracilis and Carex spp. also (Coupland, 1950; Moss, 1955). The vigor of midgrasses like Stipa comata, Agropyron smithii and Koeleria cristata, together with other palatable species, has surely declined (Moss, 1955).

In April 1954, and again in October 1955, prairie fires passed near the study area. In each case there were two very noticeable aftereffects: first, spring growth on burns was advanced at least ten days, and secondly grazing pressure was increased greatly. Both factors can be attributed to the destruction of accumulated plant residue. Plant nutrients in the resulting ash, and a more rapid warming of the ground, probably stimulated growth; further, I suspect that cattle preferred this new vegetation to the ad[illegible] of old and new elsewhere.

In the general physiognomy of the mixed-prairie community (Fig. 10), the conspicuous clumps of grass were Calamovilfa longifolia; Bouteloua gracilis and Carex heliophila constituted most of the shorter cover. On drier sites, extensive mats of Bouteloua gracilis were common, while on low prairie Agrostis scabra was more prominent.

The mixed-prairie community was replaced along shorelines or other permanently damp places by the Juncus community, and in saline areas by halophytes. The salt content of soils beneath the mixed-prairie community was negligible and the pH averaged 5.7. These soils were chiefly azonal fine to medium sands, alluvial in

Fig. 10. Typical mixed-prairie community growth; prominent grass is Calamovilfa longifolia.

origin but reworked by wind. On the crest of the moraine bordering the west side of the study area, glacial till was intermittently exposed. Here, the soil profile had a 4-in. A-horizon of brown fine sand, a 2-in. B-horizon of darker medium to fine sand, and a prominent B_{Ca} of fine to loamy sand. Pebbles were scattered throughout the profile.

Juncus Community

The Juncus community was strongly dominated by Juncus balticus, almost 85 percent of the vegetation in quadrats consisting of this species (Table 5). Hordeum jubatum ranked second in importance, followed by Carex praegracilis. The single grass regularly found in both Juncus and mixed-prairie communities was Agropyron smithii.

Grazing had little effect on the Juncus community since J. balticus, locally termed "wire grass", was seldom eaten by cattle. It is, however, a favorite bedding, and because the hollow rush-like stems of this species are easily broken, the Juncus community was often badly trampled and flattened. Stands of J. balticus were heavy (Fig. 11), averaging 225 13-in. stalks per sq. ft. (24 quadrats).

Soils of the Juncus community were usually similar to those of the mixed-prairie community, save for their additional moisture and higher pH (around 8.0). J. balticus, unlike many mixed-prairie species, tolerates appreciable rises in salinity up to about 0.5-1 percent salts.

TABLE 5.—SPECIES COMPOSITION OF THE JUNCUS COMMUNITY ON STUDY AREA FROM TWO SETS OF QUADRAT DATA 1/

Species	Percentage Total Length of Vegetation	Percentage Frequency	
	32 Quadrats— May-August 1953-54	32 Quadrats May-August 1953-54	60 Quadrats— mid-July 1956
RUSH			
Juncus balticus	84.7	100	100
GRASSES AND SEDGES			
Hordeum jubatum	9.1	96	90
Agropyron smithii	0.7	42	20
Sphenopholis obtusata			20
Agrostis stolonifera			10
Agrostis scabra			5
Stipa comata	tr.	4	5
Koeleria cristata	tr.	8	
Calamovilfa longifolia	tr.	8	
Carex praegracilis	4.2	42	70
Carex douglasii	0.1	8	
Carex spp.	tr.	4	
FORBS			
Taraxacum officinale 2/			75
Sonchus arvensis 2/			60
Aster ericoides	0.5	67	35
Solidago sp.			30
Lycopus asper			5
Plantago major			5
Potentilla anserina			5
Epilobium lineare	0.1	8	
Chrysopsis villosa	tr.	4	
SHRUBS			
Rosa sp.			5
Salix sp.			5
OTHERS			
Equisetum sp.	0.2	13	45

1/ See Appendix for sampling methods.
2/ Not included in 1953-54 quadrats.

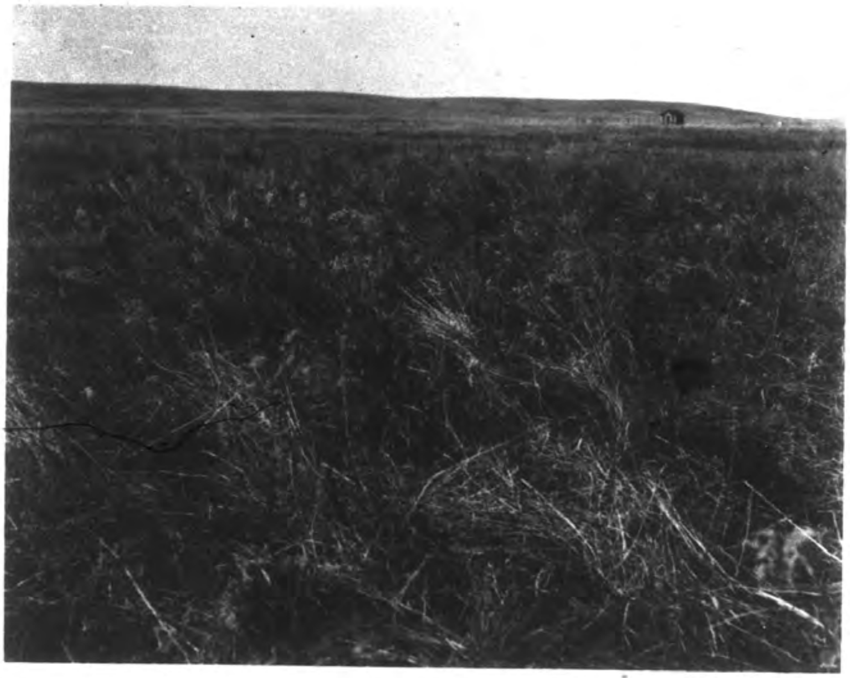

Fig. 11. Typical Juncus community growth.

Halophytic Communities

In a recent publication (Keith, 1958), vegetational changes accompanying soil salinization in this area were discussed. The conclusions reached were briefly:

1. The establishment of artificial impoundments has raised the local water table, permitting a rapid upward movement of soluble salts into surface soils from lower levels in the glacial drift.

2. The salts involved are mainly sulphates and chlorides of calcium, magnesium and sodium.

3. The salinization of shoreline areas initially results in a community dominated by Hordeum jubatum; as salts continue to accrue, this community is replaced by another in which Distichlis stricta predominates.

4. There is some evidence that pH or an associated factor becomes increasingly important in modifying plant communities once a certain level of salinity is attained.

Composition of Hordeum and Distichlis communities is given in Table 6. Neither H. jubatum nor D. stricta is relished by livestock, hence, grazing was of minor consequence. Superficially the Hordeum community appeared as a dense uniform stand of H. jubatum about 1 ft. high. The Distichlis community was, on the whole, less dense and approximately half as tall. Salicornia rubra, Suaeda depressa and Chenopodium salinum were other common species on saline mudflats.

TABLE 6.--SPECIES COMPOSITION OF THE HORDEUM AND DISTICHLIS COMMUNITIES ON STUDY AREA 1/

Species	Percentage Frequency in 20 Quadrats--mid-July 1956	
	Hordeum Community	Distichlis Community
GRASSES AND SEDGES		
Hordeum jubatum	100	
Distichlis stricta	30	100
Agropyron smithii	30	
Spartina gracilis	10	
Puccinellia nuttalliana	10	20
Calamovilfa longifolia	5	
Carex spp.	35	
FORBS		
Sonchus arvensis	40	
Taraxacum officinale	30	
Ranunculus cymbalaria	20	
Aster ericoides	10	
Aster sp.	10	
Cirsium arvense	5	
Solidago sp.	5	

1/ See Appendix for sampling methods.

Other Terrestrial Vegetation

On dams and dykes, and along trails and ditch banks, there were a great variety of "weedy" plants. Some were part of the normal succession following disturbance and some were purposely introduced. Species comprising this group were as follows:

Major Species

Cirsium arvense
Iva xanthifolia

Common Species

Agropyron smithii
Amaranthus retroflexus
Artemisia frigida
A. gnaphalodes
Axyris amaranthoides
Bromus inermis
Chenopodium album
Cleome serrulata
Descurainia sophia
Erigeron canadensis
Grindelia perennis
Hordeum jubatum
Lepidium densiflorum
Melilotus alba
Plantago major
Polygonum achoreum

Common Species (cont'd.)

P. aviculare
P. natans
Rumex crispus
R. venosus
Salsola pestifer
Solanum triflorum
Sonchus arvensis
Taraxacum officinale

Occasional Species

Echinochloa crusgalli
Helianthus annuus
Hierochloe odorata
Lygodesmia juncea
Medicago sativa
Oryzopsis hymenoides
Sporobolus cryptandrus
Thlaspi arvense
Trifolium hybridum
T. repens

In the fall of 1946, Ducks Unlimited's project manager scattered combine-screenings over several newly built dykes, hoping thereby to re-establish sufficient cover to prevent wind erosion. From all indications the plan was very successful. In addition, willow (Salix spp.) cuttings were planted on an island in D-area Lake and inside the fence of A-area during 1948. Protected from livestock, they had attained heights of 12 ft. by 1957 (Fig. 12).

Fig. 12. Aspen and willow surrounding cattail-choked pot-hole in fenced A-area.

In 1953, aspen (Populus tremuloides) was beginning to pioneer the fenced area; a few individuals were 1.5-2 ft. high. These trees were over 10 ft. and others were widespread by August 1957.

Submergent Aquatic Vegetation (Macrophytic)

General Comparison of Impoundments--Marked differences existed between submergent floras of the various impoundments (Tables 7, 8). Some of these can reasonably be ascribed to depth and salinity; others are less easily explained. One variable, often declared important in aquatic plant distribution (Chamberlain, 1948; Low and Bellrose, 1944), but not measured during the present study, was turbidity. I observed, however, that turbidity generally increased with salinity.

Submergent vegetation in D- and Cz-area Lakes was much alike at 1.5 ft. and deeper (Table 7). This might be anticipated on the basis of their similarity in depth and salinity. The main exception was Ceratophyllum demersum, which was considerably more abundant in D-area Lake. A-area Potholes, though comparable in salt concentration and depth to D- and Cz-area Lakes, had a somewhat different submergent flora. Most notable was the sharp reduction in two pondweeds, i.e. Potamogeton richardsonii and P. friesii. Both Cz-area Lake and A-area Potholes lacked Anacharis canadensis, common in D-area Lake. Since this species propagates by fragmentation (Martin and Uhler, 1939), its spread to Cz- and A-areas may only be a matter of time.

Despite higher salinity and shallower water in potholes of B-area, the submergent vegetation there strongly resembled that found in potholes of A-area (Table 7). The principal differences were the

TABLE 7.—AQUATIC VEGETATION AT DEPTHS OF 1.5 FT. OR MORE 1/

Species	Percentage Frequency in Quadrats—mid-July 1957				
	D-area Lake	Cz-area Lake	Cy-area Lake	A-area 2/ Potholes	B-area Potholes
Potamogeton richardsonii	56	48		11	11
Myriophyllum exalbescens	50	93	59	44	74
Potamogeton friesii	49	45	15	2	
Ceratophyllum demersum	33	3		52	4
Anacharis canadensis	30				
Potamogeton pusillus	19	15	9	29	36
Potamogeton pectinatus	7	7	25	5	6
Chara sp.	7			13	14
Potamogeton vaginatus	6				
Potamogeton filiformis	1			1	
Alisma gramineum			6	4	8
Ranunculus subrigidus				10	
Ruppia occidentalis			7		
Hippuris vulgaris					22
No vegetation		2	29	5	14
Total quadrats	84	60	69	126	50
Quadrats av. depth (ft.)	3.2	3.4	4.6	3.2	2.4
Water av. salinity (p.p.m.)	186	250	800	196	638
Av. pH	9.5	9.6	9.5		

1/ See Appendix for sampling method.
2/ Samples taken beyond cattail edge.

TABLE 8.—AQUATIC VEGETATION AT A DEPTH OF 1 FT.

Species	Percentage Frequency in Quadrats—early July 1957		
	D-area Lake	Cz-area Lake	Cy-area Lake
Potamogeton pusillus	93	57	2
Potamogeton richardsonii	81	71	
Myriophyllum exalbescens	72	98	92
Potamogeton pectinatus	31	26	55
Alisma gramineum	28	86	
Potamogeton filiformis	22	5	
Ceratophyllum demersum	9		
Anacharis canadensis	7		
Chara sp.	7		
Potamogeton friesii	5	2	3
Zannichellia palustris	2		
Potamogeton vaginatus		2	
Ranunculus subrigidus		12	
Polygonum coccineum		2	
No vegetation		2	
Total quadrats	58	42	60
Water av. salinity (p.p.m.)	186	250	800
Av. pH	9.5	9.6	9.5

1/ See Appendix for sampling methods.

paucity of Ceratophyllum demersum in B-area and the total absence of Hippuris vulgaris from A-area.

The submergent plant community in Cy-area Lake (Table 7) was distinct from other impoundments. Although water salinity was down to 800 p.p.m. in the summer of 1957, it had been at least twice, and perhaps three times this concentration within the previous 4 years. In view of past reports of salt tolerance among aquatics (Metcalf, 1931; Rawson and Moore, 1944), I believe that excessive salinity was responsible for the lack of Potamogeton richardsonii and Ceratophyllum demersum here and the poorer showing of P. friesii. The appearance of Ruppia occidentalis and the increase in P. pectinatus reflected the well-known halophytic character of these species.

Cy-area Lake was the only impoundment in which depths of 5.5 ft. or more were regularly encountered in sampling vegetation. Nine of 21 such quadrats contained no plant growth. Four of the five containing Ruppia occidentalis came from this zone.

Quadrats at the 1 ft. contour (Table 8) gave species-frequency values unlike those obtained at greater depths (Table 7), but re-emphasized the similarity of D- and Cz-areas, and the dissimilarity of Cy-area.

Distribution of Submergents in Relation to Depth--Distribution of seven common submergents (Fig. 13) illustrates the importance of relatively small changes in depth. Data from all quadrats taken between 1.5 ft. and 5.0 ft. were combined to give this composite picture. Two additional species, Potamogeton filiformis and Alisma gramineum, were

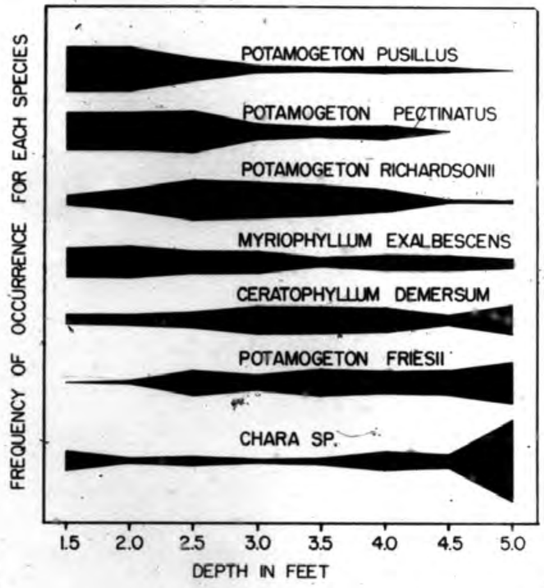

Fig. 13. Distribution of seven submergents common within study-area impoundments in relation to depth.

restricted to depths of 1.5 ft. or less and are consequently not shown. As a group, the pondweeds seldom thrived in more than 4 ft. of water. The exception, of course, was Potamogeton friesii, which was found as deep as 7.5 ft. Three other submergents, Myriophyllum exalbescens, Ceratophyllum demersum and Chara sp., exhibited a much broader spectrum of depth tolerance than most pondweeds (Fig. 13).

Lacking turbidity data as an index to light penetration, it is not meaningful to compare absolute depth ranges of species on the study area with depth ranges reported for these species elsewhere. One can, however, compare their relative distribution, and by and large, there is good agreement with past workers (Moore, 1915; Jones, 1920; Martin and Uhler, 1939).

Emergent Vegetation

Cattail--Cattail was confined to the peripheries of five ungrazed islands in D-area Lake and to the potholes of A-area. Although these potholes were developed in 1946, cattail first showed up in 1949, one year after fencing (project manager's report).

Three feet is the maximum depth to which cattail grew on the study area. McLeod et al. (1949:126) reported it rare beyond 26 in. in Manitoba marshes, and gave its optimum depth as 6 in. According to Martin et al. (1957), cattail will die out if stem bases are submerged by 4 ft. of water for more than a year. Between 1949 and 1957, this plant spread rapidly in A-area, occupying 9.7 ac. (48 percent) of water, and 9.6 ac. (22 percent) of unflooded ground (Fig. 14). The

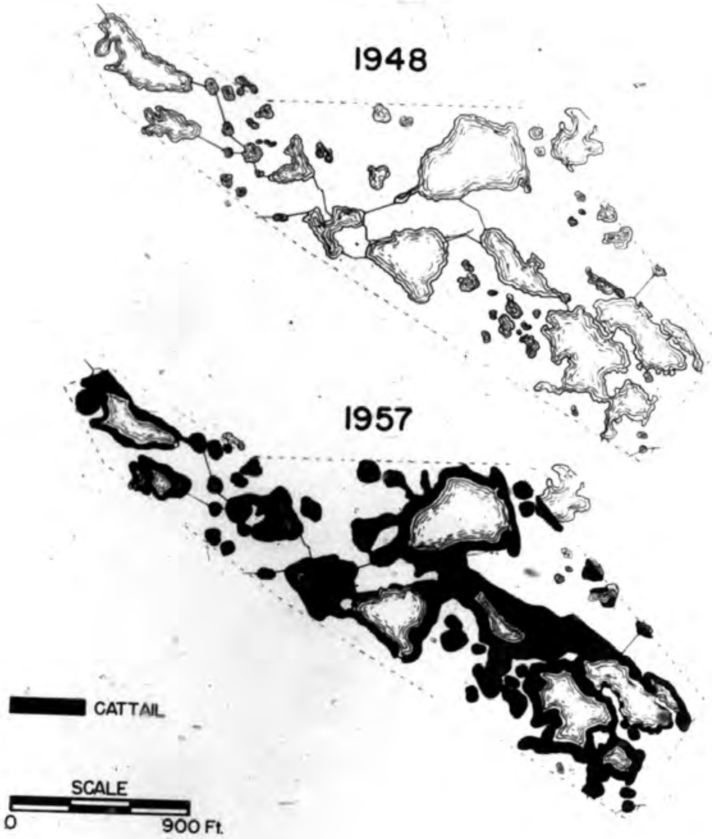

Fig. 14. Development and spread of cattail in A-area Potholes after fencing.

cattail edge advances approximately 3 ft. per year, vegetatively, in depths up to 3 ft. If it reaches the 3-ft. contour in A-area Potholes, only about 6 ac. (30 percent) of their original surface will be visible.

During the summer of 1955, D-area Lake was held at a low level, and I had an opportunity to observe cattail establishment. The mudflats of D-area provided ideal conditions for germination and growth of seedlings, and by the end of June, large numbers of young cattail plants were present. On July 1, 1,850 head of cattle were turned into the 10,000-ac. pasture containing the study area. The cattail was immediately subjected to heavy grazing and trampling that continued throughout the rest of the season. In mid-August, the lake was raised 18 in. to its normal level. With the exception of a small patch of cattail which developed on an island of exposed mudflat, none of this new growth was seen the following year. The island of cattail that did survive was ungrazed and had attained a height of 2.5-3.0 ft. by mid-August. A year afterwards, this stand was firmly established (Fig. 15) and flowering.

I infer from the above observations that cattle effectively check the development of cattail shorelines by grazing and trampling the young seedlings, and that this likely prevents them from storing sufficient food reserves to over-winter and/or to send up new shoots the next spring. It is, I think, significant that incipient stands of cattail did not occur along the edge of Cy-area Lake during the extended periods when saline mudflats existed.

Fig. 15. Stand of cattail originally established when low water levels exposed a mudflat island inaccessible to livestock.

Although livestock can completely inhibit the establishment of new cattail growth along shorelines, they are largely ineffective once vegetative reproduction of this species begins. At that stage, rhizones send up shoots in deeper water, where grazing is too light to have any appreciable effect. Also, the coarser stalks of old plants are undoubtedly less palatable than seedlings.

Cattail in A-area underwent very heavy trampling in November 1953. On first viewing this condition in early May 1954 (Fig. 16), I felt certain that the stand had received a definite setback. Yet, by the middle of June, it was as high and as dense as ever.

In many places where good muskrat populations occur, cattail is continually thinned out (Bennett, 1938a; Cartwright, 1946); and in some marshes extensive "die-offs" or "eat-outs" are precipitated by these rodents (Lynch <u>et al.</u>, 1947; Giltz and Myser, 1954). Muskrats were plentiful on the study area but had very little effect on cattail. There were two reasons for this: (1) muskrats dwelt in bank burrows and seldom built houses, and (2) other aquatic foods were abundant and seemingly preferred. Excavated burrows, for example, were invariably packed with <u>Myriophyllum</u> <u>exalbescens</u> and softstem bulrush.

Other aquatic vegetation is much more limited in heavy cattail growth than in sparser stands, or at similar depths in open water. Sections of A-area in which cattail had been reduced by herbicides a year earlier were compared with untreated sections of the same potholes. Submergents greatly increased on treated sites (Table 9).

<u>Softstem Bulrush</u>—Softstem bulrush was introduced into several impoundments by Ducks Unlimited field personnel. It has survived only in water

Fig. 16. **A-area cattail stand in early May 1954** after being badly trampled by cattle during the previous fall.

TABLE 9.--AQUATIC VEGETATION IN SPRAYED AND UNSPRAYED CATTAIL STANDS OF A-AREA AT A DEPTH OF 1 FT. 1/

Species	Percentage Frequency in 30 Quadrats in Cattail	
	Sprayed	Unsprayed
Ceratophyllum demersum	53	37
Myriophyllum exalbescens	50	10
Potamogeton pusillus	30	7
Potamogeton richardsonii	17	
Alisma gramineum	13	
Potamogeton pectinatus	7	
Eleocharis palustris		7
Drepanocladus sp.		3

1/ Sprayed August 1955, see Appendix for sampling method. Quadrats taken in mid-July 1957.

deep enough to deter cattle, or where protected by fences. As far as I was able to determine, these plantings have spread very little. In D-area Lake most stands were in 4 ft. of water and on a firm sand bottom.

Cattle preferred softstem bulrush to cattail, and when given the opportunity, quickly grazed it down. Muskrats also exhibit a definite preference for softstem bulrush (McLeod, 1949:126), and in D-area Lake were frequently noted carrying stalks of this plant 150-300 yd. to their burrows. In the majority of cases, cattail was much closer but was ignored.

May counts of muskrats seen in D-area Lake at sunset, provided a yearly index to population levels. In May 1954, the average number of muskrats per count was 13.2 (20 counts); none of the previous year's bulrush growth was visible in spring, and new stalks were cut down almost as fast as they appeared. Numbers in May 1955 averaged 4.4 (10 counts); muskrats were shot and trapped during that month and the June average fell to 1.0 (6 counts). A heavy stand of softstem developed, but when control measures ceased at the end of June, a rapid ingress of animals took place, decimating the stand within 3 weeks. May counts averaged 9.1 (7 counts) in 1956, and the story was similar to that in 1954. During 1957, mean numbers per count dropped to 3.5 (8 counts); for the first time since the study began, some of the past year's growth was visible in spring, and during summer an excellent stand developed.

Summary

Most terrestrial vegetation was arbitrarily grouped into three major plant communities, viz. mixed prairie, Juncus, and halophytic. Dominant species of the mixed-prairie community were Bouteloua gracilis, Calamovilfa longifolia, Stipa comata and Carex spp. The Juncus community was composed largely of Juncus balticus, and was found along shorelines and in other permanently damp situations. The two main halophytic communities were dominated by Hordeum jubatum and Distichlis stricta. Most soils beneath the mixed-prairie and Juncus communities were azonal sands. Salinization has occurred around some impoundments and in these areas halophytes were encountered. Potamogeton spp., Myriophyllum exalbescens, Ceratophyllum demersum and Chara sp. were the most common submergent aquatics. D- and Cz-area Lakes had submergent floras that were much alike, as did A- and B-area Potholes. Cy-area Lake was floristically very different from the other impoundments, apparently as a result of its higher salinity. Few pondweeds thrived in more than 4 ft. of water, the exception being Potamogeton friesii. Cattail stands quickly developed on ungrazed shorelines and penetrated impoundments to depths of 3 ft. Between 1949 and 1957, cattail invaded almost 50 percent of the water surface in A-area Potholes. Muskrats had little effect on cattail, but were responsible for a continual decimation of softstem bulrush.

FOOD HABITS

Despite wide recognition of the mixed prairie in southern Saskatchewan and Alberta as one of the continent's most productive waterfowl breeding grounds, nothing has been published on natural foods of ducks in this region. The most comprehensive food-habits studies to date, involving samples from Alberta and Saskatchewan, were conducted by Cottam (1939) and Martin and Uhler (1939). In these investigations, however, collections were not made on the mixed prairie, but rather in parkland, mountain, or boreal regions; and the exact geographic origin of even these data has been lost through combination with samples from Manitoba, British Columbia and the Northwest Territories.

Our present knowledge of waterfowl food habits is very deficient in two categories, i.e. for adults on the breeding grounds during spring and summer, and for all age classes of ducklings. The main reason for this seems to be a hesitancy among biologists to collect breeding birds or their young. This attitude is esthetically understandable, yet the problem could easily be resolved if, in future, stomachs were preserved from some of the adult ducks and ducklings that regularly die in summer banding operations.

With any study of this type, there are a number of limitations and possible sources of error. The more important among these are:

1. Digestion of some foods, particularly soft-bodied invertebrates and fragile parts of plants is more rapid than digestion of

hard seeds. The former are thus less apt to be noted in stomach contents.

2. It is extremely difficult to secure an accurate picture of relative abundance of food items without intensively sampling aquatic and moist-soil vegetation and taking into account seeds, etc. lying on the bottom or windrowed along the shore.

3. The great mobility of waterfowl throughout much of the year may lead to their feeding many miles from the place of collection.

4. Certain items are doubtless unintentionally ingested during feeding and can hardly be considered selected food.

I was concerned primarily with natural foods in this investigation, although, as will be discussed later, some cultivated crops on nearby irrigated farmland are seasonally important to mallards and pintails.

Methods

Collection of Specimens--Ducks for stomach analyses were taken from a 30-sq.-mi. block surrounding and including the study area. All were collected in the vicinity of Ducks Unlimited impoundments. Of the 221 stomachs I examined, 186 were secured in spring and summer under migratory-bird collecting permits issued by the Canadian Wildlife Service, 18 were shot during the regular hunting season, and 17 were killed by predators. Predator-kills were utilized as I had no reason to believe their food habits aberrant.

Contents of the gizzard and proventriculus of each duck were transferred to containers, either 2-oz. bottles or small cotton bags, and stored in 10 percent Formalin. Each sample was given a number and labeled as to species, sex, age group, place collected, how obtained and date.

Seeds from aquatic and shoreline plants were gathered to serve as a reference collection. I am indebted to A. C. Martin and F. M. Uhler of the United States Fish and Wildlife Service, for identifying specimens that I overlooked in making this collection but found later in duck stomachs.

Analysis of Stomach Contents--There are several published guides to food-habits analysis. Techniques outlined by Cottam (1936) and Martin (1949) are basic, but each worker usually introduces a few modifications to meet his particular requirements. Through trial and error the methods employed by me evolved into the routine given in the Appendix.

Treatment of Data--In summarizing food habits, I have grouped the data into four classes--percentage volume, percentage occurrence, importance value, and preference rating.

Percentage volume expresses the total volume of each food item from a particular group of stomachs as a percentage of the total volume of organic material present. Percentage occurrence is the number of stomachs in which a particular item was found, expressed as a percentage of the total stomachs examined.

Importance value is defined as the product of percentage volume times percentage occurrence. While both percentage volume and percentage occurrence are important indices to food habits, it is obvious that under certain circumstances each can be misleading when considered separately. If, for example, one stomach contained large quantities of a species rarely eaten, the volume contributed by this stomach alone might be sufficient to give that species a sizable percentage volume in the final tabulation. If, on the other hand, an item occurred frequently but in small amounts, its value as suggested by percentage occurrence would be much exaggerated. Multiplying these two percentages together tends to negate such effects, except in extreme cases, while producing a single statistic--the importance value—which takes both sets of data into account. Beck (1952) came to much the same conclusion working with food habits of wild turkeys.

A preference rating for each major food species was obtained by dividing its importance value by its estimated percentage abundance. Bellrose and Anderson (1943) and Stoudt (1944) followed essentially the same procedure. I have simply used importance value where the others used percentage volume.

Percentage abundance values were based on data from the transects and quadrats in aquatic and shoreline plant communities, and on general impressions of seed production and availability. Transect and quadrat information is helpful in determining percentage abundance, but needs to be interpreted cautiously. One must consider such things as (1) relative seed production by various species, (2) yearly variations in seed production, and (3) resistance of seeds to decomposition. I have attempted to evaluate these factors objectively, and feel that my estimations of percentage abundance are sufficiently accurate to justify their usage.

Foods Eaten

In the following summary of food habits, ducks have been divided into three major groups, viz. dabblers other than baldpates and gadwalls, divers, and baldpates and gadwalls. This segregation, as will be seen shortly, is based on fundamental differences in diet. Among the dabblers, enough stomachs were collected to permit a further breakdown of data into adult, flying-juvenile and duckling age classes.

Foods of Dabblers Other Than Baldpates and Gadwalls—Seeds and fruits of aquatic and shoreline plants were the chief foods of adult dabblers during spring and summer (Table 10). Leading species consisted of spike-rush, water milfoil and pondweeds. Other important foods were sedges, *Juncus balticus*, softstem bulrush, and alkali bulrush. The relatively favorable position of *J. balticus* in Table 10 is somewhat misleading and is due largely to a single mallard stomach that was packed with capsules from this species.

While the same plants--water milfoil, pondweeds and spike-rush—comprised the principal diet of flying juveniles (Table 11), the importance of water milfoil increased markedly and that of spike-rush and pondweeds fell. The higher proportion of finely ground organic matter in stomachs of flying juveniles as compared to adults suggests an increased usage of soft foods.

Food habits of ducklings (Table 12) leaned strongly towards spike-rush, which contributed over half the volume of all seeds and fruits consumed. Seeds of sedges were second in importance, followed by the large-seeded pondweeds and water milfoil. The heavy utilization

TABLE 10.--NATURAL FOODS EATEN DURING SPRING AND SUMMER BY ADULTS OF FIVE DABBLING SPECIES 1/

Scientific Name	Common Name	% Volume	% Occurrence	Importance Value
IDENTIFIABLE PLANT MATERIAL 2/				
Eleocharis palustris	Spike-rush	6.74	72	485
Myriophyllum exalbescens	Water milfoil	6.77	61	413
Potamogeton spp. 3/	Small-seeded pondweeds	8.34	45	375
Potamogeton spp. 4/	Large-seeded pondweeds	8.76	36	315
Carex spp. 5/	Sedges	3.17	53	168
Juncus balticus	Baltic rush	7.15	20	143
Scirpus validus	Softstem bulrush	2.57	41	105
Scirpus paludosus	Alkali bulrush	2.37	36	85
Chenopodium spp. 6/	Goosefoot	1.15	16	18
Polygonum spp.	Smartweeds	1.55	9	14
Hordeum jubatum	Wild barley	0.13	14	
Potamogeton spp.	Pondweed (tubers)	1.68	2	
Ruppia occidentalis	Western wigeon-grass	0.11	11	
Hippuris vulgaris	Mare's tail	0.09	11	
Scirpus americanus	Three-square bulrush	0.09	8	10
Ranunculus subrigidus	White water crowfoot	0.02	20	
Rumex sp.	Dock (flower glands)	0.12	5	
Alisma gramineum	Water plantain	0.06	6	
Ceratophyllum demersum	Coontail	0.04	2	
Rumex spp.	Dock	0.02	2	
Total		50.93		
ANIMAL MATTER AND UNIDENTIFIABLE ORGANIC MATERIAL				
Gastropoda				
Lymnaea sp.	Snails		8	
Hemiptera				
Notonecta sp.	Backswimmers		5	
Diptera				
Chironomidae	Midge (larvae)	5(est.)	3	
Cladocera				
Daphnia sp.	Waterflea (egg cases)		3	
Insecta				
(unidentified)	Insects		3	
Unidentifiable finely ground organic material		44(est.)	100	
Total		49.07		

Table continued on next page

1/ 64 stomachs: 19 pintails, 18 mallards, 14 blue-winged teal, 7 shovelers, 6 green-winged teal.

2/ Seeds or fruits unless otherwise indicated.

3/ Shallow-water species: *P. pusillus*, *P. filiformis*.

4/ Deeper-water species: *P. richardsonii*, *P. pectinatus*, *P. vaginatus*, *P. friesii*, *P. zosteriformis*.

5/ Mainly *C. praegracilis*, *C. douglasii*, *C. aquatilis*, *C. atherodes*.

6/ Mainly *C. salinum*.

TABLE 11.--NATURAL FOODS EATEN DURING SUMMER AND FALL BY FLYING JUVENILES OF FOUR DABBLING SPECIES 1/

Scientific Name	Common Name	% Volume	% Occurrence	Importance Value
IDENTIFIABLE PLANT MATERIAL 2/				
Myriophyllum exalbescens	Water milfoil	10.23	70	716
Potamogeton spp. 3/	Small-seeded pondweeds	4.97	55	273
Eleocharis palustris	Spike-rush	3.99	45	180
Potamogeton spp. 4/	Large-seeded pondweeds	4.58	25	115
Juncus balticus	Baltic rush	4.51	10	45
Carex spp. 5/	Sedges	1.45	30	44
Scirpus validus	Softstem bulrush	0.51	25	13
Scirpus americanus	Three-square bulrush	1.33	10	13
Hordeum jubatum	Wild barley	0.18	25	
Polygonum spp.	Smartweeds	0.09	10	
Potamogeton spp.	Pondweed (tubers)	0.08	5	
Hippuris vulgaris	Mare's tail	0.06	5	6
Scirpus paludosus	Alkali bulrush	0.03	5	
Ruppia occidentalis	Western wigeon-grass	0.03	5	
Ranunculus subrigidus	White water crowfoot	trace	10	
Chenopodium spp. 6/	Goosefoot	trace	5	
Total		32.04		
ANIMAL MATTER AND UNIDENTIFIABLE ORGANIC MATERIAL				
Identifiable animal material			0	
Unidentifiable finely ground organic material		67.96	100	
Total		67.96		

1/ 20 stomachs: 9 pintails, 6 mallards, 4 shovelers, 1 blue-winged teal.
2/ Seeds or fruits unless otherwise indicated.
3/ Shallow-water species: *P. pusillus*, *P. filiformis*.
4/ Deeper-water species: *P. richardsonii*, *P. pectinatus*, *P. vaginatus*, *P. friesii*, *P. zosteriformis*.
5/ Mainly *C. praegracilis*, *C. douglasii*, *C. aquatilis*, *C. atherodes*.
6/ Mainly *C. salinum*.

TABLE 12.—NATURAL FOODS EATEN DURING SUMMER BY DUCKLINGS OF FOUR DABBLING SPECIES 1/

Scientific Name	Common Name	% Volume	% Occurr-ence	Impor-tance Value
IDENTIFIABLE PLANT MATERIAL 2/				
Eleocharis palustris	Spike-rush	27.08	68	1,841
Carex spp. 3/	Sedges	7.40	59	437
Potamogeton spp. 4/	Large-seeded pondweeds	8.27	41	339
Myriophyllum exalbescens	Water milfoil	4.37	58	253
Potamogeton spp. 5/	Small-seeded pondweeds	1.40	27	38
Scirpus validus	Softstem bulrush	1.18	32	38
Scirpus paludosus	Alkali bulrush	0.90	25	
Alisma gramineum	Water plantain	1.09	9	
Juncus balticus	Baltic rush	0.51	17	
Hippuris vulgaris	Mare's tail	0.51	15	
Ranunculus subrigidus	White water crowfoot	0.60	9	
Distichlis stricta	Alkali grass	1.08	2	
Hordeum jubatum	Wild barley	0.32	5	59
Ceratophyllum demersum	Coontail	0.24	3	
Chenopodium spp. 6/	Goosefoot	0.04	5	
Polygonum spp.	Smartweeds	0.01	5	
Gramineae	Misc. grass seeds	0.02	2	
Ruppia occidentalis	Western wigeon-grass	0.01	2	
Scirpus americanus	Three-square bulrush	0.01	2	
Total		55.04		
ANIMAL MATTER AND UNIDENTIFIABLE ORGANIC MATERIAL				
Gastropoda				
Lymnaea sp.	Snails		11	
Gyraulus sp.	Snails		5	
Insecta (unidentified)	Insects	10(est.)	11	
Hemiptera				
Notonecta sp.	Backswimmers		5	
Unidentifiable finely ground organic material		35(est.)	100	
Total		44.96		

Table continued on next page

1/ 66 stomachs: 33 pintails--Class III (13), II (9), I (11); 20 mallards--Class III (13), II (5), I (2); 11 blue-winged teal--Class III (4), II (4), I (3); 2 shovelers--Class III (1), II (1).

2/ Seeds of fruits unless otherwise indicated.

3/ Mainly C. praegracilis, C. douglasii, C. aquatilis, C. atherodes.

4/ Deeper-water species: P. richardsonii, P. pectinatus, P. vaginatus, P. friesii, P. zosteriformis.

5/ Shallow-water species: P. pusillus, P. filiformis.

6/ Mainly C. salinum.

of spike-rush, and the marked increase in importance of sedges reflects the tendency of broods to feed mainly along shorelines, whereas adults and flying juveniles feed more on open water. Neither spike-rush nor sedges in this area commonly occurred at water depths greater than 6 in.

Animal matter constituted only a small percentage of the total food intake of these dabblers. Class-I ducklings (see under Brood Counts for classification), however, ingested relatively fewer seeds and a higher proportion of soft organic material and animal matter than did class-II and class-III ducklings. The limited consumption of animal matter cannot be attributed to scarcity as most impoundments teemed with aquatic insects and other invertebrates.

Foods of Divers--Food habits of adult divers (Table 13) differed in several respects from those of adult dabblers. Divers consumed more water milfoil, western wigeon-grass (*Ruppia occidentalis*) and animal matter (chiefly bottom organisms), and less spike-rush, sedge and *Juncus balticus* than did dabblers.

The explanation for these differences rests once again, I believe, on the feeding distribution and behavior of the birds. It is well known that diving ducks frequent deeper waters and feed off the bottom, while dabblers prefer shallows where aquatic vegetation reaches the surface or where bottom feeding may be accomplished by simply "tipping up." Since water milfoil and wigeon-grass are the two species most commonly found in deep waters, one might anticipate their greater usage by divers. Conversely, spike-rush, sedges and *J. balticus* are plants of shallow waters and shorelines, and consequently

TABLE 13.--NATURAL FOODS EATEN DURING SPRING AND SUMMER BY ADULTS OF FOUR DIVING SPECIES 1/

Scientific Name	Common Name	% Volume	% Occurrence	Importance Value
IDENTIFIABLE PLANT MATERIAL 2/				
Myriophyllum exalbescens	Water milfoil	21.25	88	1,870
Potamogeton spp. 3/	Large-seeded pondweeds	5.32	62	330
Potamogeton spp. 4/	Small-seeded pondweeds	4.02	75	302
Scirpus paludosus	Alkali bulrush	3.61	33	119
Ruppia occidentalis	Western wigeon-grass	2.83	38	108
Eleocharis palustris	Spike-rush	0.96	50	48
Scirpus validus	Softstem bulrush	0.84	38	32
Hordeum jubatum	Wild barley	0.69	17	
Ceratophyllum demersum	Coontail	1.06	4	
Carex spp. 5/	Sedges	0.09	33	
Rumex sp.	Dock (flower glands)	0.10	17	
Juncus balticus	Baltic rush	0.07	13	22
Polygonum spp.	Smartweeds	0.05	8	
Scirpus americanus	Three-square bulrush	0.05	4	
Chenopodium spp. 6/	Goosefoot	0.02	8	
Hippuris vulgaris	Mare's tail	0.02	4	
Ranunculus subrigidus	White water crowfoot	trace	4	
Total		40.98		
ANIMAL MATTER AND UNIDENTIFIABLE ORGANIC MATERIAL				
Diptera				
Chironomidae	Midge (larvae)		21	
Cladocera				
Daphnia sp.	Waterflea (egg cases)	20(est.)	8	
Trichoptera	Caddis fly (larvae)		8	
Gastropoda				
Gyraulus sp.	Snails		8	
Unidentifiable finely ground organic material		39(est.)	100	
Total		59.02		

1/ 24 stomachs: 9 redheads, 8 scaups, 5 ruddy ducks, 2 canvasbacks.
2/ Seeds or fruits unless otherwise indicated.
3/ Deeper-water species: P. richardsonii, P. pectinatus, P. vaginatus, P. friesii, P. zosteriformis.
4/ Shallow-water species: P. pusillus, P. filiformis.
5/ Mainly C. praegracilis, C. douglasii, C. aquatilis, C. atherodes.
6/ Mainly C. salinum.

are used more by dabblers.

Foods of Baldpates and Gadwalls—Unlike other dabbling ducks and the diving ducks, baldpates and gadwalls made little use of seeds and fruits in their diet (Tables 14, 15, 16), the only seeds of any consequence being those of spike-rush. As far as I was able to discern, the leaves and stems of grasses and submergent aquatics composed the staple diet of these birds. Potamogeton pusillus and P. friesii, seemed to be preferred.

The only indication of animal-matter consumption among adults was obtained from a single gadwall drake and a pair of spring-shot baldpates, which had gorged themselves on egg cases of a Cladoceran (Daphnia sp.). Such egg cases were occasionally observed in large floating masses and windrows.

Foods of Geese—While no concerted effort was made to collect geese for stomach analysis, five specimens were secured incidentally. Three Canada geese were shot during October; another, a flightless adult, was killed in July by a dog; and the last was picked up dead on the study area in late June. Some feeding observations were also made.

Each of the geese examined by me had fed almost exclusively on blades of grass, principally Hordeum jubatum. Canada geese were observed feeding on H. jubatum and Distichlis stricta, and dwarf spike-rush (Eleocharis acicularis) was eaten extensively as it appeared on newly exposed mudflats. I noted two snow geese on the open prairie at least a mile from the nearest water on June 20, 1958. They flew off when approached but I suspect they had been grazing.

TABLE 14.--NATURAL FOODS EATEN DURING SPRING AND SUMMER BY ADULT BALDPATES AND GADWALLS 1/

Scientific Name	Common Name	% Volume	% Occurrence	Importance Value
IDENTIFIABLE PLANT MATERIAL 2/				
Eleocharis palustris	Spike-rush	6.56	21	138
Juncus balticus	Baltic rush	0.58	8	
Scirpus paludosus	Alkali bulrush	0.40	13	
Hordeum jubatum	Wild barley	0.17	13	
Scirpus validus	Softstem bulrush	0.15	13	
Chenopodium spp. 3/	Goosefoot	0.07	21	
Gramineae	Misc. grass seeds	0.12	4	17
Carex spp. 4/	Sedges	0.03	13	
Myriophyllum exalbescens	Water milfoil	0.04	8	
Potamogeton spp. 5/	Large-seeded pondweeds	0.02	8	
Scirpus americanus	Three-square bulrush	0.02	4	
Potamogeton spp. 6/	Pondweeds	0.02	4	
Ranunculus cymbalaria	Seaside buttercup	0.01	8	
Total		8.19		
ANIMAL MATTER AND UNIDENTIFIABLE ORGANIC MATERIAL				
Cladocera				
Daphnia sp.	Waterflea (egg cases)	27.71	13	
Unidentifiable finely ground organic material 7/		64.10	100	
Total		91.81		

1/ 24 stomachs: 12 baldpates, 12 gadwalls.
2/ Seeds or fruits unless otherwise indicated.
3/ Mainly *C. salinum*.
4/ Mainly *C. praegracilis*, *C. douglasii*, *C. aquatilis*, *C. atherodes*.
5/ Deeper-water species: *P. richardsonii*, *P. pectinatus*, *P. vaginatus*, *P. friesii*, *P. zosteriformis*.
6/ Shallow-water species: *P. pusillus*, *P. filiformis*.
7/ A large amount of this consisted of fragments of stems and leaves of pondweeds and grasses.

TABLE 15.--NATURAL FOODS EATEN DURING SUMMER AND FALL BY FLYING JUVENILE BALDPATES AND GADWALLS 1/

Scientific Name	Common Name	% Volume	% Occurrence	Importance Value
IDENTIFIABLE PLANT MATERIAL 2/				
Eleocharis palustris	Spike-rush	8.24	50	412
Scirpus validus	Softstem bulrush	1.13	33	37
Potamogeton spp. 3/	Small-seeded pondweeds	0.88	33	29
Myriophyllum exalbescens	Water milfoil	1.63	17	28
Scirpus paludosus	Alkali bulrush	0.60	17	
Carex spp. 4/	Sedges	0.30	33	
Alisma gramineum	Water plantain	0.42	17	
Potamogeton spp. 5/	Large-seeded pondweeds	0.17	17	33
Hordeum jubatum	Wild barley	0.09	17	
Chenopodium spp. 6/	Goosefoot	0.05	17	
Ranunculus subrigidus	White water crowfoot	0.01	17	
Total		13.52		
ANIMAL MATTER AND UNIDENTIFIABLE ORGANIC MATERIAL				
Identifiable animal material			0	
Unidentifiable finely ground organic material 7/		86.48	100	
Total		86.48		

1/ 6 stomachs: 3 baldpates, 3 gadwalls.
2/ Seeds or fruits unless otherwise indicated.
3/ Shallow-water species: *P. pusillus*, *P. filiformis*.
4/ Mainly *C. praegracilis*, *C. douglasii*.
5/ Deeper-water species: *P. richardsonii*.
6/ Mainly *C. salinum*.
7/ Fragments of pondweed stems and leaves constituted part of this material.

TABLE 16.--NATURAL FOODS EATEN DURING SUMMER BY BALDPATE AND GADWALL DUCKLINGS 1/

Scientific Name	Common Name	% Volume	% Occurrence	Importance Value
IDENTIFIABLE PLANT MATERIAL 2/				
Carex spp. 3/	Sedges	0.15	40	19
Juncus balticus	Baltic rush	0.21	20	
Potamogeton pectinatus	Pondweed	0.16	20	
Potamogeton pusillus	Pondweed	0.11	20	
Lycopus asper	Western water horehound	0.10	20	
Myriophyllum exalbescens	Water milfoil	0.06	20	
Total		0.79		
ANIMAL MATTER AND UNIDENTIFIABLE ORGANIC MATERIAL				
Insecta (unidentified)	Insects	10(est.)	20	
Unidentifiable finely ground organic material		89(est.)	100	
Total		99.21		

1/ 5 stomachs: 3 gadwalls--Class II (1), I (2); 2 baldpates--Class III (2).
2/ Seeds or fruits unless otherwise indicated.
3/ Mainly C. praegracilis, C. douglasii.

Interspecific Differences in Food Habits of Adult Ducks--Importance values of plants listed in Table 17 suggest differences in food habits within the major groups of ducks considered earlier. In view of the small sample sizes, however, the validity of these differences cannot be accepted at this time.

Preference Ratings of Plant Foods--It is not always easy to explain why seeds and fruits of one species are preferred over those of another. Probably size, shape, hardness, texture and "taste" have much to do with palatability. Accessibility, nutritional value, conditioning, and perhaps the physiological state of the bird must also be considered.

McAtee (1918) regarded availability as the most important factor in choice of food; Bellrose and Anderson (1943) stated that "availability, as measured by food yield and accessibility, determines the value of most plants generally considered as sources of duck food." Further, they declared that "palatability plays an important role in determining the food value of several species." Stoudt (1944) pointed to the need for studies on nutritive values of preferred duck foods, and like Bellrose and Anderson (1943), gave examples of plants which were available but obviously not utilized.

That waterfowl will react promptly to changes in the accessibility of seeds, was dramatically illustrated on three occasions during the present study. Slowly falling water levels throughout July and early August had, in each instance, exposed extensive beds of pondweeds and other submergents. The pondweeds, and possibly

TABLE 17.—SUMMARY OF PLANT FOODS EATEN DURING SPRING AND SUMMER BY ADULT DUCKS AS INDICATED BY IMPORTANCE VALUES

Scientific Name 1/	Pin. (19)2/	Mal. (18)	B-w.T. (14)	Shov. (7)	G-w.T. (6)	Bald. (12)	Gad. (12)	Scaup (8)	R.H. (9)	Ruddy (5)
Eleocharis palustris	157	267	2,012	1,389	469	290		21	45	106
Myriophyllum exalbescens	473	320	744	184	77			2,800	1,288	1,896
Potamogeton spp. 3/	347	762	2	30	5		5	719	65	7
Potamogeton spp. 4/	654	240	237	4	255			150	450	62
Carex spp. 5/	205	98	48	640	202		2	3	2	5
Scirpus validus	7	175	78	693	19	5		4	86	6
Scirpus paludosus	140	14	63	81	130	3	1	560	5	
Juncus balticus	17	383	12	19	13	13			5	
Chenopodium spp. 6/					947	3				
Ruppia occidentalis	2		3	4				392	8	37
Hordeum jubatum	4	3			3		17	2	15	71
Polygonum spp.	63				5			1		
Rumex sp. 7/				20				5		3
Scirpus americanus			2	20					1	
Ranunculus subrigidus			6		18					
Alisma gramineum			1	11						
Potamogeton sp. 8/		26								
Ceratophyllum demersum									23	
Hippuris vulgaris			17							
Rumex sp.					6					
Gramineae 9/							4			
Ranunculus cymbalaria						4				

Table continued on next page

1/ Seeds or fruits unless otherwise indicated.
2/ Sample size.
3/ Large-seeded, deeper-water species: P. richardsonii, P. pectinatus, P. vaginatus, P. friesii, P. zosteriformi .
4/ Small-seeded, shallow-water species: P. pusillus, P. filiformis.
5/ Mainly C. praegracilis, C. douglasii, C. aquatilis, C. atherodes.
6/ Mainly C. salinum.
7/ Dock (flower glands).
8/ Pondweed (tubers).
9/ Unidentified grass seeds.

some of the other species as well, responded to this drying with heavy seed production. When a gradual inundation was begun in mid-August, dabbling-duck numbers rapidly increased from less than 50 to concentrations of 500-1,000. Subsequent stomach analyses of 18 birds collected at that time indicated they had been feeding largely on pondweed seeds. These floated to the surface and were readily available as reflooding occurred.

Seeds of spike-rush were the preferred food in the current study (Table 18). This species has one characteristic which may bear on its high preference rating, i.e. its growth form. Spike-rush is a shallow-water emergent, often growing in dense stands. The seeds are borne in short terminal spikes, 6 in.-1 ft. above the water. Furthermore, the stem is not strong and the spike is easily pulled from it. When feeding, ducks simply swim into the stands and pluck off the seed-bearing spikes.

The three leading food plants in the preference rating (Table 18) are emergent or moist-soil species. Bellrose and Anderson (1943) assumed that seeds of moist-soil and emergent species were more accessible to waterfowl than those of submergent aquatics, and later Low and Bellrose (1944) proved that the seed yield of moist-soil and emergent species was substantially greater.

Although abundant and available, muskgrass, coontail and three-square bulrush were little used by ducks. Both Stoudt (1944) and Mendall (1949a) have commented on the seeming avoidance of muskgrass and coontail by ducks, but Martin and Uhler (1939) list musk-

TABLE 18.—PREFERENCE OF DUCKS 1/ FOR PRINCIPAL FOOD PLANTS

Scientific Name 2/	Importance Value	Approx. % of Abundance 3/	Preference Rating 4/
Eleocharis palustris	842	5	168
Scirpus validus	43	1	43
Carex spp. 5/	173	5	35
Myriophyllum exalbescens	398	25	16
Potamogeton spp. 6/	153	10	15
Potamogeton spp. 7/	225	20	11
Scirpus paludosus	42	10	4
Juncus balticus	41	25	2

1/ 209 stomachs: all species and all age groups.
2/ Seeds or fruits.
3/ Approximate % abundance as compared with other species in this table.
4/ Importance value divided by % abundance.
5/ Mainly *C. praegracilis*, *C. douglasii*, *C. aquatilis*, *C. atherodes*.
6/ Small-seeded, shallow-water species: *P. pusillus*, *P. filiformis*.
7/ Large-seeded, deeper-water species: *P. richardsonii*, *P. pectinatus*, *P. vaginatus*, *P. friesii*, *P. zosteriformis*.

grass third as a food in western Canada, preceded only by pondweeds and bulrushes.

Seasonal Changes in Food Habits--Food habits of adult ducks in May (before advent of the current year's seed production) are compared with food habits during June, July and August (Table 19). The species of ducks in Table 19 were chosen because a number of stomachs from each had been collected during both periods.

It is necessary to decide at what point differences between the two columns of importance values in Table 19 have significance. Certainly, relative differences between large importance values will be more significant than those between smaller ones. With this in mind, and viewing the limited sample sizes, I believe that only for sedges does consumption really differ in the two periods shown here. Their importance value in June, July and August is approximately twenty times that in May. Why sedges should prove to be exceptional in this regard, I cannot say.

The constancy of usage of other foods might be interpreted in one of two ways: (1) that waterfowl were held to the same diet by a limited food supply consisting of species whose relative availability did not change appreciably over the season, or (2) that sufficient seeds of each food species were available throughout the spring and summer to permit waterfowl to exercise freely their preferences, and that these preferences did not change. I favor the latter alternative, first because there is an abundance of edible seeds produced by food plants in this region and, as Bellrose and

TABLE 19.--PLANT FOODS EATEN DURING MAY AS COMPARED WITH JUNE, JULY AND AUGUST BY ADULTS OF SEVEN SPECIES 1/

Scientific Name	May Importance Value	June, July, and Aug. Importance Value	Ratio of Seasonal Importance Values 2/
Potamogeton spp. 3/	1,176	1,066	0.91
Myriophyllum exalbescens	859	835	0.97
Eleocharis palustris	348	133	0.38
Scirpus paludosus	138	50	0.36
Scirpus validus	78	58	0.74
Ruppia occidentalis	8	24	3.00
Carex spp. 4/	8	155	19.38

1/ 38 stomachs in May, 37 stomachs in June, July, Aug.: 19 pintails, 18 mallards, 14 blue-winged teal, 9 redheads, 8 scaups, 4 ruddy ducks, 2 canvasbacks.

2/ May importance values divided into importance values for June, July, and Aug.

3/ Includes all species of *Potamogeton* present.

4/ Mainly *C. praegracilis*, *C. douglasii*, *C. aquatilis*, *C. atherodes*.

Anderson (1943) have shown, such seeds remain available to ducks from one year to the next; and secondly because the relative availability of various seeds is probably changing continually as one plant species after another matures.

Usage of Cultivated Crops--The fall stubbling flights of mallards and pintails are well known on the Canadian prairies. In recent years the swather and combine have replaced the binder and threshing machine, and reports of serious crop damage by waterfowl have increased. The problem of duck depredations is complex (Bossenmaier and Marshall, 1958) and will not be discussed here. Greatest losses usually occur when combining is delayed by wet weather and grain must be left in the swath for extended periods.

Field feeding by mallards and pintails occurs also in spring prior to cultivation, although such feeding is not nearly so intensive as in the fall (Bossenmaier and Marshall, 1958). Of 18 stomachs collected in May, only 4 contained grain and all were from drakes. In October, 9 of 12 mallards and pintails shot in the same area had fed on grain. I suspect two factors are mainly responsible for reduced spring utilization of cultivated crops, viz. the smaller quantities of grain available in spring, and the limited home range of breeding waterfowl at that time (Dzubin, 1955).

It is my impression that in this region "stubble-ducks" prefer barley, and that field peas are a close second followed by wheat and oats. The preference for barley may be largely conditioned since this is usually the first crop swathed. During 1954, acreages of these crops in the Eastern Irrigation District were: wheat—32,800, barley--28,700, oats--21,600 and field peas--3,730 (District Agriculturist, in litt.).

General Discussion of Food Plants

Major Food Species--The present investigation has disclosed the local importance of water milfoil and spike-rush, two species generally considered of limited food value to waterfowl.

Water milfoil is a widely distributed submergent tolerating appreciable ranges of depth and salinity. Other investigators have reported this plant of little or no consequence to ducks. Their studies were, of course, based largely on fall stomachs; but even when spring and summer collections were made, this species remained unimportant. Stoudt (1944), working in Minnesota, regarded water milfoil as a plant "not relished," and Mendall (1949a) indicated that it was common but not eaten in Maine. Its best rating was by Martin and Uhler (1939) who listed it fifth in importance in western Canada, behind pondweeds, bulrushes, muskgrasses and smartweeds. The current heavy utilization of milfoil, especially by diving ducks, emphasizes that food habits may exhibit great inter-regional variation, and that a particular species should not be discounted until data from all parts of its range have been considered.

Although various spike-rushes are valuable waterfowl foods in some areas (Singleton, 1951; Yocum, 1951), on the whole they have made only a minor contribution. It was thus surprising to find *Eleocharis palustris* second only to all species of pondweeds as a food for adult dabblers in this region, and comprising more than one-quarter of the total food intake of ducklings.

The other major spring and summer foods encountered here—pondweeds, sedges and bulrushes—are of paramount importance in many parts of North America. An examination of results from 18 previous studies 1/ in Canada and the United States revealed that pondweeds,

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1/ Bellrose and Anderson (1943); Bennett (1938b); Cottam (1939); Coulter (1955, 1957); Crawford (1938); Martin and Uhler (1939); Mendall (1949a, 1958); Munro (1944, 1949); Pirnie (1935); Scheffer and Hotchkiss (1945); Singleton (1951); Stollberg (1950); Stoudt (1944); Yocom (1951); Zimmerman (1953).

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bulrushes and sedges, in that order were the leading foods.

Since waterfowl food habits have not been investigated on other parts of the mixed prairie, one can only speculate on the representativeness of present findings. The principal food plants on the study area are all common in lakes and potholes throughout the mixed-prairie region. One factor that affects such vegetation profoundly is salinity. Rawson and Moore (1944) correlated the absence of a number of common submergents with salinity in several Saskatchewan lakes, and Keith (1958) noted changes in shoreline vegetation on the present study area resulting from increasing soil salinity. It is thus clear that no two water areas are going to support identical hydrophytic communities; and probably food habits will vary accordingly. The stomach contents of 122 molting adult pintails taken recently at Pel Lake, Saskatchewan, on the mixed prairie-parkland border, tend to support this view (Keith, unpublished data). Over 57 percent of the identifiable food material consumed by these ducks consisted of seeds from alkali bulrush, a common species in moderate to strongly saline waters.

Establishment of Food Plants--The following remarks on the establishment of waterfowl food plants are based mainly upon my observations on the Will J. Reid study area, and several adjacent projects in southeastern Alberta. While different conditions may be encountered elsewhere, conclusions drawn here are probably valid for the majority of impoundments developed in this region.

I am convinced that there is no shortage of plant or animal food for waterfowl in most lakes and potholes of the study area. Pondweed seeds are commonly windrowed in early spring, and the dense seed-laden spikes of pondweeds and water milfoil are seen everywhere by the end of June. One of the earliest and most productive pondweeds is Potamogeton filiformis, a species seldom growing in more than a foot of water. Spike-rush, though less abundant than the submergents, is plentiful and usually seed bearing by mid-June; sedges also abound in the moist shoreline soils. Invertebrates, particularly snails, leeches, crustaceans and various insect larvae are present in great numbers on submergent vegetation and in bottom debris.

Between 1946 and 1949, the following aquatics were planted on the study area by Ducks Unlimited personnel: wild celery (Vallisneria americana), wild rice (Zizania aquatica), sago pondweed (Potamogeton pectinatus), three-square bulrush, and softstem bulrush. The first two species were well beyond their natural ranges and, although exhibiting good summer growth, apparently winter-killed. Severe grazing may have contributed to the failure of wild rice (D.U. Files). The remainder survived and persist to the present time. Softstem bulrush was primarily introduced to provide nesting cover for diving ducks but, as noted before, it had considerable food value.

Judging from the great variety of other food species that rapidly pioneered these waters, it is questionable whether plantings were necessary. As early as 1947, only two years after D-area Lake and A-area Potholes were first flooded, and prior to Ducks Unlimited's introductions of sago pondweed and bulrushes, aquatic vegetation was reported abundant (C. H. Foster, D.U. Files). When the current investigation began in 1953, 12 emergent and 14 submergent species were present, including 7 species of pondweeds. Many seeds and vegetative parts capable of initiating new growth were undoubtedly carried here through the water supply. Where shorelines are grazed during the growing season, however, it is difficult for the conspicuous and palatable softstem bulrush to become established. The only stands on the study area arise either from rootstalks planted in water sufficiently deep to discourage livestock, or from plantings and natural seedings in fenced areas. Even when protected from grazing animals, these stands have done rather poorly, being severely thinned by muskrats. Spike-rush and three-square bulrush are also eaten by livestock but continue to thrive.

Any immediate benefit to emergent and shoreline food plants that might be derived from fencing is bound to be short-lived. Once livestock are excluded, cattail quickly appears and eventually monopolizes peripheral waters to depths of 3 ft. Softstem bulrush persists but does not spread when surrounded by cattail. Spike-rush also vanishes, and submergents with the exception of coontail are drastically reduced. Dabblers may fare worst as a result of cattail invasion for shallow feeding areas are virtually eliminated.

The phenomenon of increasing salinity in some newly flooded areas has been mentioned previously. Many aquatics important to waterfowl will not tolerate excessively saline conditions. In impoundments on or near the study area, for example, only sago pondweed, western wigeon-grass, three-square bulrush and alkali bulrush were found in waters containing over 3,000 p.p.m. salts. The six remaining pondweeds were absent at salinities of 1,000 p.p.m., and both water milfoil and spike-rush disappeared between 2,000 and 3,000 p.p.m. Leitch (1951) referring to Saskatchewan lakes stated: "The salinity of some of these lakes . . . has increased to a point where they are of little use to waterfowl, except as concentration areas for stubbling birds in spring and fall."

Grit

The grit from each gizzard was separated into three size groups (gravel, fine gravel and sand) and measured volumetrically. This separation was carried out with 2-mm.-mesh and 1-mm.-mesh sieves.

Grit Size--The first four species of adult dabblers in Table 20—mallards, pintails, shovelers and blue-winged teal—exhibited progressive decreases in average grit size with decreasing body size. Yocum

TABLE 20.—SIZE AND QUANTITY OF GRIT IN GIZZARDS OF ADULT DUCKS

Species	Percentage of Grit in Gizzard			Average Quantity of Grit (ml.)
	Gravel (>2 mm.)	Fine Gravel (2 mm. to 1 mm.)	Sand (<1 mm.)	
Mallard (17) 1/	12 ± 4 2/	60 ± 9	28 ± 10	1.74
Pintail (19)	6 ± 2	55 ± 11	39 ± 12	1.16
Shoveler (7)	2 ± 3	51 ± 26	46 ± 29	0.66
Blue-winged teal (14)	3 ± 1	44 ± 14	53 ± 14	0.45
Redhead (9)	6 ± 3	65 ± 6	29 ± 7	1.93
Scaup (8)	10 ± 9	47 ± 22	44 ± 26	1.03
Gadwall (10)	0	5 ± 2	96 ± 2	1.49
Baldpate (12)	1 ± 2	9 ± 5	90 ± 6	1.49

1/ Number of gizzards.
2/ 95% confidence limits.

(1951) noted the frequent occurrence of large pebbles in mallard gizzards, and commented on the finer texture of pintail grit. Confidence limits on mean percentage volumes overlap widely between species, reflecting both limited sample size and appreciable variance within species.

Variations in average grit size between age classes are small and lack consistent trends (Table 21), although, there is a tendency for the gizzards of adult mallards and pintails to contain a higher percentage of gravel than is found in duckling gizzards.

The average grit size for baldpates and gadwalls is strikingly different from that of other ducks in Table 20, i.e. there is a definite change to the smaller fractions. This coincides with the equally striking difference in food habits already discussed. and it seems reasonable to suspect a direct relationship between the two factors.

The mechanism regulating size of grit in gizzards is not known. Ellarson (1956) observed that the ratios of sand to gravel, and food to grit were remarkably constant in old-squaw ducks. He pointed out that birds could hardly avoid ingesting grit when feeding and concluded: "These constant ratios between food and grit and between sand and gravel strongly suggest some internal mechanism regulating the grit retention of the gizzard."

The pronounced difference between grit size in baldpates and gadwalls compared to other species largely precludes gizzard grit as being merely a random sampling of available material. The bill

TABLE 21.—SIZE AND QUANTITY OF GRIT IN STOMACHS OF PINTA[illegible]S AND MALLARDS IN RELATION TO AGE CLASSES

Species	Age Class	Percentage of Grit in Gizzard: Gravel (>2 mm.)	Fine Gravel (2 mm. to 1 mm.)	Sand (<1 mm.)	Average Quantity of Grit (ml.)
Pintails	Adult (19) 1/	6 ± 2 2/	55 ± 11	39 ± 12	1.16
	Flying Juv. (9)	1 ± 1	44 ± 16	55 ± 17	1.81
	Class III (12)	2 ± 2	65 ± 13	33 ± 14	0.59
	Class II (7)	1 ± 1	53 ± 30	46 ± 30	0.36
	Class I (7)	0	45 ± 22	55 ± 22	0.17
Mallards	Adult (17)	12 ± 4	60 ± 9	28 ± 10	[illegible]74
	Flying Juv. (6)	12 ± 10	58 ± 18	30 ± 24	2.03
	Class III (13)	4 ± 2	67 ± 10	29 ± 10	1.07
	Class II (5)	7 ± 7	60 ± 25	34 ± 29	0.86

1/ Number of gizzards.
2/ 95% confidence limits.

and tongue are unquestionably able to sort grit within certain limits, however, I feel as did Ellarson (1956) that substantial quantities of grit must be accidentally swallowed during feeding. The sandy bottoms of lakes and potholes in the study-area region greatly enhanced this possibility. Amounts of grit so ingested by prairie ducks are probably much lower than among old squaws on Lake Michigan, but these are probably enough to mask any purposeful selection by the bill and tongue. Thus, the major variations in gizzard grit, noted above, are accountable only if one postulates a selective retention of some grit sizes by the gizzard.

Quantity of Grit--The average quantity of grit present (Tables 20, 21) is a function of gizzard size. The seeming contradiction presented by flying-juvenile pintails and mallards (Table 21) is actually no exception, since average gizzard size among these birds was greater than adults. This is attributable to the fact that gizzards of adults collected in spring were much smaller than those of adults and flying juveniles taken later on.

Presence of Lead Shot--Lead shot was found in gizzards of the following adults:

Pintails	1 of 19	Scaups	1 of 8
Mallards	1 of 18	Redheads	3 of 9
(5%)	2 of 37	(23%)	4 of 17

One of the redheads had ingested two pellets, the five other birds only one apiece. The seemingly higher percentage of gizzard shot among divers is typical of findings elsewhere (Reid, 1948; Elder, 1950; Bellrose, 1951). Five of these ducks were collected in early May and one in June. Hunting pressure here is very light and pellets were most likely picked up on the wintering grounds or during spring migration.

A gadwall secured on the study area in mid-October was the only flying juvenile with lead shot in the gizzard. None occurred in ducklings.

Increasing Gizzard Size Among Adults—The length, depth, and width of a number of gizzards was measured immediately after removal. This practice was begun in 1956 to determine the relative size of the gizzard in each species, so that possible relationships between gizzard size and grit size and/or quantity could be investigated. It soon became clear that the size of this organ did not remain constant, but increased greatly from May through September. Measurements were continued in 1957, and weights of emptied gizzards were determined as well.

An index to gizzard volume was secured by multiplying length, depth, and width. Within a species the smallest index value for each sex was divided into other index values to give the relative changes in size depicted in Fig. 17. Data for a species were included in Fig. 17 only when these were available from at least four birds of the same sex, one of which had been collected in May.

The calculated regression line indicated a nearly threefold increase in gizzard size between the beginning of May and the end of September. Gizzard weight increased at an even greater rate. A comparison of weight and measurement data on 21 adult gizzards

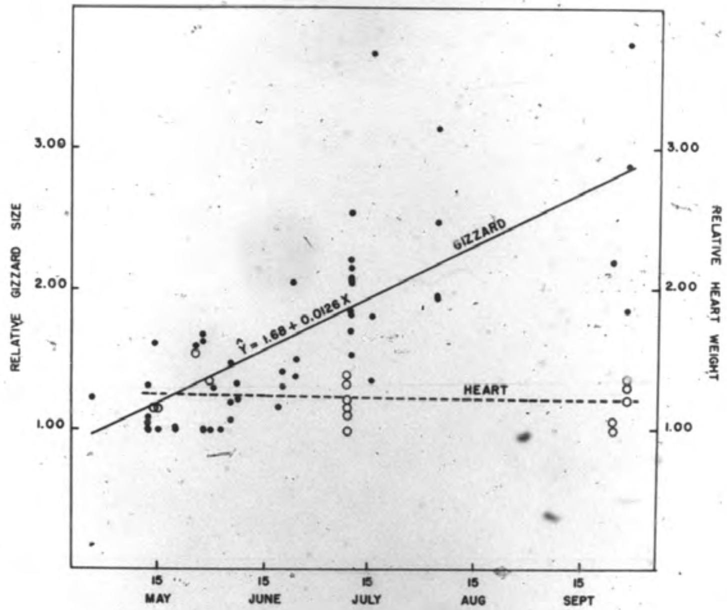

Fig. 17. Relative increase in size (length x width x depth) of gizzard of adult ducks from May to September inclusive.

revealed a gain of 1.4 in relative weight for each gain of 1.0 in relative size. This difference may mean that increased gizzard size involved chiefly a thickening of the gizzard wall, without a proportionate enlargement of the lumen. Unfortunately, no lumen measurements were taken. Multiplying the threefold increase in size shown in Fig. 17 by 1.4 gives an approximate fourfold gain in weight during this 5-mo. period. Relative heart weights (Fig. 17) displayed no change over the same length of time.

Leopold (1953) correlated differences in intestine and caecum length with diet among California quail; and Breitenbach (1956) reported that fall and early-winter weight gains by pheasants were due primarily to enlargement of the gastro-intestinal tract and related organs. It is not too surprising then that gizzard weight should undergo seasonal changes in waterfowl. I suspect that major variations except for those in the reproductive organs are, as among pheasants, associated with the digestive system. However, until we have the complete picture, hypotheses regarding their significance are bound to be tenuous.

Summary

Stomachs of 221 ducks were collected between May and October, 1953-57, from a 30-sq.-mi. block on the mixed prairie of southeastern Alberta. Basic differences in diet are discussed for three major groups of ducks viz. dabblers other than baldpates and gadwalls, divers, baldpates and gadwalls. Among the dabbling species, data were further subdivided into adult, flying-juvenile, and duckling age classes. Seeds and fruits of aquatic and moist-soil plants constituted the staple diet of ducks in this study; only small quantities of animal matter were utilized. Adult and juvenile dabblers other than baldpates and gadwalls ate chiefly seeds of spike-rush, water milfoil and pondweeds. Over one-quarter of the total organic matter consumed by ducklings of this group consisted of spike-rush seeds. Baldpates and gadwalls of all age classes utilized few seeds of any kind, appearing to subsist mainly on leaves and stems of pondweeds and grasses. Seeds of water milfoil and, to a lesser extent, of pondweeds were the principal food of adult divers. Five Canada goose stomachs that were examined contained leaves of grasses, primarily *Hordeum jubatum*. A preference rating of the eight leading food plants in the study indicated that spike-rush was most preferred. Food habits in May (before initiation of the current year's seed production) did not vary appreciably from those in June, July, and August. Cultivated grains and field peas are used extensively by mallards and pintails in fall and to a lesser extent in early spring. The discovery that water milfoil and spike-rush were important foods, is

largely contrary to findings in studies conducted elsewhere. Rapid pioneering by aquatic plant species in this area generally makes waterfowl food plantings unnecessary. Cattail stands which develop after fencing, eventually eliminate most useful food plants. The size and quantity of grit in duck stomachs was measured. Grit in gadwalls and baldpates was much finer than in other ducks; this appears to be correlated with the absence of seeds in the diet of the former two species. For some reason, presently not understood, gizzards of adult ducks exhibited an approximate fourfold increase in weight during the period from May to September inclusive.

BREEDING POPULATION

Counts of adult ducks were made on the study area for three principal reasons: (1) to determine species composition and distribution of the breeding population, (2) to determine population levels, and (3) to investigate waterfowl response to changes in shoreline type.

Methods

Adult Duck Counts—A total census of adult ducks was attempted on impoundments of the study area's five subdivisions. The route taken during counts (Fig. 18) caused a minimum of disturbance to the birds, but afforded the observer an excellent view of all water areas. There was usually little difficulty seeing where ducks that were scared from impoundments alighted. When this happened to be on one of the lakes or potholes not yet censused, due allowance was made.

Censuses were conducted between 8 a.m. and 12 noon using 7x35 or 7x50 binoculars. The entire circuit required 2.5 hr. to complete. In 1953, counts were begun on May 22; thereafter they began on May 4-6. Counts were terminated each year on July 15. By that date the few remaining males were in eclipse plumage and often hard to distinguish from females; also, some of the early-hatched ducklings were becoming difficult to segregate from adults. The number of counts made in various years was: 15—1953, 50—1954, 32—1955, 32—1956, 30—1957. All ducks, except hens flushed from nests or with broods, were listed as to species and sex. Subdivision tallies were kept separate. Breeding-pair estimates were based on these counts.

Fig. 18. Route taken when censusing adult ducks on study-area impoundments.

General Population Data

Arrival Dates--Of the eight commonest species of ducks, pintails were first and blue-winged teal were last to arrive each spring (Table 22). As Hickey (1943:24) pointed out, first migrants generally exhibit greater year-to-year variation in date of arrival than do later migrants. Sowls (1955:12) illustrated this principle with five dabbling species at Delta, Manitoba. Waterfowl reach the Brooks district of Alberta a week earlier than Delta, on the average, but in the same species sequence.

The white-winged scoter was the final species to appear on the study area. From 1953 to 1957 respectively, it was first noted on May 28, May 18, May 9, May 10, and May 7. The range of 21 days seems extreme for such a late migrant.

Sex Ratios--Sex ratios of five species prior to nesting are shown in Table 23. Ratios for blue-winged teal (57:43), scaups (63:37), and ruddy ducks (67:33) are close to those noted by Furniss (1938) among breeding populations in the vicinity of Prince Albert, Saskatchewan. A gadwall sex ratio of 52:48 (510 birds), similar to the 53:47 observed in the present study, was reported by Johnsgard and Buss (1956) in Washington during February 15-May 16, 1954.

The sex ratio of 320 drive-trapped pintail ducklings that I examined in 1957 was 53:47. For 1,427 bait-trapped scaup ducklings banded (1940-1953) by Ducks Unlimited at Ministik Lake, Alberta, the sex ratio was 43:57 (D.U. Files).

Species Composition--Lesser scaups and blue-winged teal comprised roughly 50 percent of counted individuals (Table 24). However, these

TABLE 22.--SPRING ARRIVAL DATES FOR EIGHT SPECIES OF DUCKS IN REGION OF STUDY AREA

Species	Dates of First Spring Observations 1/					Range (Days)
	1953	1954	1955	1956	Av.	
Pintail	Mar. 22	Apr. 1	Mar. 22	Mar. 25	Mar. 25	10
Mallard	Mar. 23	Apr. 3	Mar. 23	Mar. 28	Mar. 27	11
Baldpate	Mar. 30	Apr. 5	Mar. 29	Mar. 26	Mar. 30	10
Shoveler	Apr. 10	Apr. 7	Apr. 9	Apr. 2	Apr. 7	8
Redhead	Apr. 13	Apr. 12	Apr. 12	Apr. 7	Apr. 11	6
Gadwall	Apr. 8	Apr. 12	Apr. 15	Apr. 12	Apr. 12	7
Scaup	Apr. 12	Apr. 16	Apr. 13	Apr. 9	Apr. 13	7
Blue-winged teal	Apr. 25	Apr. 29	Apr. 28	Apr. 23	Apr. 26	6

1/ Average of dates provided by Fred Sharp at Tilley, Alberta, and T. E. Randall at Brooks, Alberta.

TABLE 23.--SPRING SEX RATIOS OF FIVE SPECIES OF DUCKS ON STUDY AREA 1953-57 1/

Species	Early May Until 8 Days Before 50% of Successful Clutches Initiated			Early May until 1 Day Before 50% of Successful Clutches Initiated		
	Males	Females	Ratio	Males	Females	Ratio
Gadwall	241	210	53:47	370	329	53:47
Redhead	198	156	56:44	389	301	56:44
Blue-winged teal	332	235	59:41	891	680	57:43
Scaup	2,422	1,468	62:38	3,384	2,025	63:37
Ruddy				520	259	67:33 2/

1/ Determined from regular counts of adult birds on study-area impoundments.

2/ Sex ratios from counts through May; no ruddy ducks were known to begin laying prior to early June.

species are late nesters and May to mid-July counts tend to exaggerate their relative abundance somewhat. In this respect, breeding-pair estimates provide a more satisfactory index of population composition. The average number of pairs per year was 155, viz. 38 scaups, 31 blue-winged teal, 22 pintails, 16 mallards and 49 pairs of 7 other species (Table 25).

Adult Mortality--Activities associated with different phases of the study resulted in frequent and intensive coverage of all of the study area, and dead ducks were often seen. Most of these dead birds appeared to have been eaten by predators, although some of this "predation" could have been merely the work of scavengers. The true fraction of mortality attributable to predation, to disease and parasites, or to a combination of these is not known.

The mean number of adult males per count in 1956 and 1957 was 220; censused impoundments constituted approximately 72 percent of the study area's shoreline, hence there were perhaps 86 additional drakes on other waters. During these 2 years, a record was kept of all ducks found dead. Thirteen dead drakes were encountered between May 6 and July 15--the period when counts were being made. The mortality rate during this time, as calculated from these data, would be about 2 percent each year. This is, of course, a fairly crude statistic, but unquestionably a conservative one.

The mean number of adult females per count in 1956 and 1957 was 101. When adjustment is made for uncensused impoundments, the average for the entire study area is approximately 140. Thirteen

TABLE 24.—SPECIES COMPOSITION OF ADULT DUCKS COUNTED ON STUDY-AREA IMPOUNDMENTS MAY TO MID-JULY, 1953-57

Species	Av. Number of Adult Ducks Per Count						Percentage Composition of Population					
	1953	1954	1955	1956	1957	Av.	1953	1954	1955	1956	1957	Av.
Scaup	69	45	120	81	136	90	31	19	37	31	34	31
Blue-winged teal	46	53	56	50	66	54	20	23	17	19	16	19
Pintail	22	33	30	18	33	27	10	14	9	7	8	9
Gadwall	9	19	25	23	36	22	4	8	8	9	9	8
Mallard	13	12	19	16	28	18	6	5	6	6	7	6
Baldpate	16	14	18	17	25	18	7	6	5	6	6	6
Redhead	12	11	19	16	30	18	5	5	6	6	8	6
Shoveler	10	16	14	14	18	14	4	7	4	5	5	5
Ruddy	12	10	9	12	16	12	5	4	3	5	4	4
Green-winged teal	7	5	7	6	4	6	3	2	2	2	1	2
White-winged scoter	8	2	4	1	2	3						1
Canvasback	1	3	1	4	3	2						1
Unidentified 1/		9	2	1	1	3						1
Others 2/	1	1	2	1	1	1						<1
Total	226	233	326	260	399	288						

1/ Mainly drake dabblers.
2/ Mainly nonbreeding buffle-heads.

TABLE 25.--ESTIMATED NUMBER OF PAIRS OF DUCKS USING STUDY-AREA IMPOUNDMENTS, 1953-57

Species	Pairs of Ducks						Percentage Composition					
	1953	1954	1955	1956	1957	Av.	1953	1954	1955	1956	1957	Av.
Scaup	28	21	44	35	62	38	25	13	28	27	29	25
Blue-winged teal	23	42	29	26	33	31	21	26	18	20	15	20
Pintail 1/	11	42	20	16	24	22	10	26	13	12	11	14
Mallard	13	16	11	12	30	16	12	10	7	9	14	10
Redhead	9	8	10	11	20	12	8	5	6	8	9	8
Gadwall	5	10	10	8	14	9	4	6	6	6	7	6
Shoveler	8	6	9	6	13	8	7	4	6	5	6	5
Baldpate	6	5	9	8	11	8	5	3	6	6	5	5
Ruddy	6	4	8	4	4	5	5	2	5	3	2	3
Green-winged teal	2	4	5	2	2	5	2	2	3	2	1	3
Canvasback	1	3	2	3	1	2	1	2	1	2	<1	1
Total pairs	112	161	157	131	214	155						

1/ Pair estimates probably not as accurate as for later-nesting species.

hens were picked up dead between May 6 and July 15, a mortality of 5 percent. Another 3 percent were killed on nests. Hen mortality thus totalled about 8 percent during a time when drake mortality amounted to about 2 percent.

It is uncommon to witness direct acts of predation, even under ideal field conditions. In five summers I saw only three ducks taken by raptors, one each by a duck hawk, a rough-legged hawk and a red-tailed hawk.

I once noticed two coyotes slowly skirting the shoreline of Cy-area Lake, and producing an effect like the tolling dogs employed by European decoy operators. Ducks were swimming over and paralleling the coyotes' movements at a distance of around 15 ft. Every 100 yd. or so the coyotes would suddenly lunge into the water. This frightened the ducks temporarily, but within a few minutes they were back again. None was captured on this occasion.

As far as could be determined, weasels accounted for a high percentage, if not all, of the hens killed on nests.

Population Levels

Mean Population Levels on Study-Area Subdivisions—Adult duck populations on each subdivision of the study area exhibited different trends (Fig. 19). Duck numbers on the largest lake (D) were highest in early May and declined rapidly and steadily thereafter. Much of this decline was likely caused by a dispersal of breeding pairs into pothole areas with the onset of nesting. A- and B-area potholes, for example, initially gained both males and females as numbers on D-area

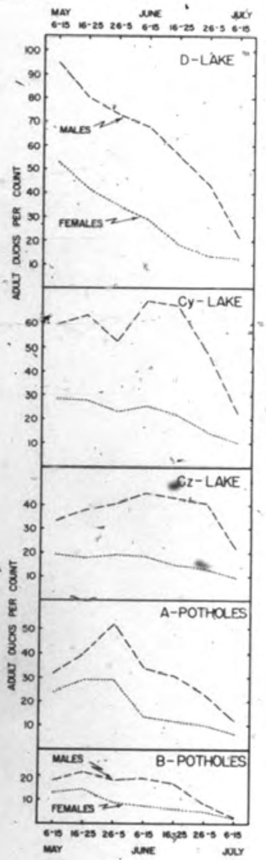

Fig. 19. Average population trends for adult ducks on impoundments of the study area's five subdivisions, May to mid-July, 1953-57.

Lake fell. Furthermore, greatest nest densities were found in pothole areas. The attractiveness of such areas to waterfowl during this period must have been at least partly a function of superior nesting cover--the result of fencing and an abundant Juncus community.

Usage of impoundments by hens was likely influenced to a considerable extent by nest location (Dzubin, 1955; Sowls, 1955:49). Many drakes, on the other hand, were soon free of breeding ties and able to wander about as they chose until the flightless stage of the summer molt. During the interval between the breakup of the pair bond and shortly before the flightless period, large numbers of drakes were attracted to mudflat areas. Here they spent most of the day loafing, sleeping and preening. The sharp rise in the male population curve for Cy-area Lake (June 6-15) reflects its usual mud-type shore line. Average numbers of drakes on Cz-area Lake and B-area Potholes displayed a less pronounced but similar trend for probably the same reason.

Flocks of postbreeding pintail and mallard drakes were first to concentrate on the mudflats. They were succeeded by shovelers, baldpates, blue-winged teal, gadwalls and scaups. Important "molting" lakes (Hochbaum, 1944:123) were situated 15 mi. to the southwest (Lake Barkhausen) and 40 mi. to the southeast (Louisiana Lakes). By mid-July, the male segment of the population had fallen to about one-third of its peak level, and was composed chiefly of scaups and gadwalls.

Annual Population Levels on Study Area--The average number of adult ducks per count ranged from a low of 226 in 1953 to a high of 399 in

1957 (Table 24). The estimated number of pairs was 112 in 1953 and 214 in 1957 (Table 25). Adult-male population trends were not always alike from year to year (Fig. 20). In 1953 and 1955, extensive mudflats on the study area resulted in a noticeable influx of drakes during June. In 1954 and 1956, water levels were maintained at a generally higher level, and mudflats were greatly reduced. No appreciable ingress of drakes occurred. Numbers of adult females per count underwent a slow but continuous decline from May to mid-July during 1953-56, caused by the progressive initiation of nesting in the various species.

Drought conditions prevailed throughout southern Alberta in 1957, and most natural potholes in the region of the study area were dry before mid-May. Study-area water levels remained near those of the previous year. Between May 16 and May 25, instead of the customary 10 percent decrease, the duck population rose 20 percent due to an influx of birds of either sex representing all species. It seems logical that these were birds which had been forced to abandon their original nesting areas as adjacent ponds dried up. Nesting started exceptionally early in 1957 and was well underway, even among scaups, by the last week in May. While it is conceivable that some of the new ducks renested, I obtained no evidence of this from the nesting study or from subsequent brood counts. Hatching curves were earlier and confined to a shorter period than in any of the ~~four~~ preceding years.

Average Use of Study-Area Subdivisions by Pairs, 1954-57—Utilization of impoundments by pairs of 11 species varied considerably (Fig. 21).

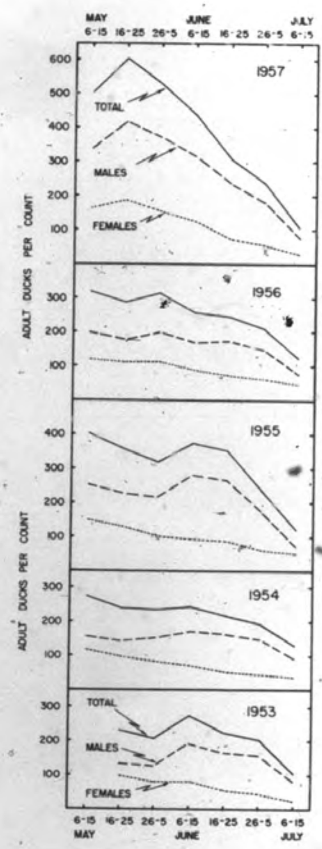

Fig. 20. Average yearly population trends for adult ducks on censused impoundments of the study area, May to mid-July, 1953-57.

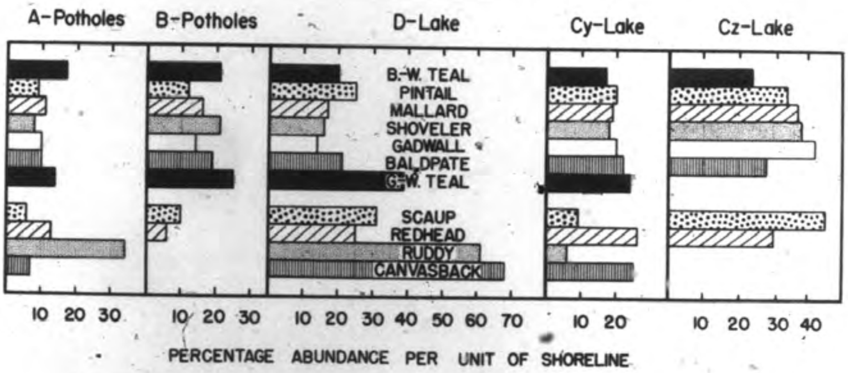

Fig. 21. Average usage of different impoundments of study area by pairs, 1954-57. Percentage abundance is the average number of pairs per 1,000 yd. shoreline, expressed as a percentage of: Σaverage pairs per 1,000 yd. shoreline on each of the study area's five subdivisions.

A-area Potholes with their cattail peripheries supported fewest dabblers per unit of shoreline. Bue et al. (1952), speaking of stock ponds in South Dakota, suggested that the development of tall emergents may reduce the number of breeding pairs. Evans (1952) reported comparatively low usage of cattail-fringed potholes by breeding pairs near Minnedosa, Manitoba.

On the whole, dabblers frequented D- and Cy-area Lakes and B-area Potholes to nearly the same extent, notwithstanding differences in shoreline type, kinds and abundance of submergent food plants, and free water surface. I am unable to explain the relatively high use of Cz-area Lake. Its salinity, submergent aquatics, and shoreline type and vegetation closely resembled D-area Lake. The only obvious difference between these two impoundments was the smaller size of the former. Blue-winged teal utilized all impoundments to approximately the same degree (Fig. 21), thus corroborating Sowl's (1955: 75-76) observations on ditch-type use at Delta, Manitoba.

Ruddy ducks were limited to D-area Lake and A-area Potholes--waters with emergent cattail and softstem bulrush. Although half the canvasback nests were located in cattail surrounding A-area Potholes, few adults were seen there. Most were observed on the two largest lakes (D and Cy). Redheads preferred the lakes to the potholes; and for some reason, Cy-area Lake was far less attractive to scaups than were D- and Cz-area Lakes.

Response of Ducks to Changes in Shoreline Type

Effect of Rush-Grass vs. Mud Shorelines in Breeding Season--Spring waterfowl populations reacted inconsistently or not at all to major shoreline changes caused by fluctuating water levels (Tables 26, 27). During 1954-57, the percentage abundance of female dabblers per unit of shoreline remained at 17-18 percent on D-area Lake, and at 22-25 percent on Cy-area Lake. The shorelines of each alternated from mud to rush-grass, and vice versa, over the 4-year period.

Numbers of adult dabblers fell sharply on Cz-area Lake in 1956 and increased sharply in 1957. Such fluctuations had no known connection with shoreline changes, as similar changes, here and on Cy- and D-area Lakes, elicited no response among waterfowl in other years.

The percentage abundance of male and female diving ducks per unit of shoreline varied little on Cz-area Lake during 1954-57. Diver populations were highest on D-area Lake in 1956, when rush-grass shorelines replaced the mud type of the previous summer. The same sequence of shoreline types failed to affect usage of Cz-area Lake in 1954. Cy-area Lake was least attractive to divers in 1954 and 1956; in each of these years, mud shorelines in spring had been preceded by mud shorelines the summer before. The significance of this is difficult to evaluate since comparable conditions never occurred elsewhere on the study area.

<u>Effect of Reflooding Mudflat Areas in Mid-August</u>--Mudflats that had expanded through the spring and summer as water levels fell, were slowly reflooded in mid-August on three separate occasions, viz., 1953--Cz-area Lake, 1954--Cy-area Lake, and 1955--D-area Lake. In each case the response of adult and flying-juvenile dabblers was

TABLE 26.—USAGE OF THREE STUDY-AREA LAKES BY ADULT DABBLERS 1/, FROM MAY TO MID-JULY, IN RELATION TO SHORELINE TYPE

Average Shoreline Type		Time of Water Level Change	Percentage Abundance 2/ Per Unit of Shoreline								
			Cz-Lake			D-Lake			Cy-Lake		
Spring	Previous Summer		Male	Female	Year	Male	Female	Year	Male	Female	Year
Rush-grass 3/	Rush-grass		37	35	1955	15	17	1957			
Rush-grass	Mud 4/	Mid-August	32	34	1954	22	18	1956	23	22	1955
Rush-grass	Mud	September	22	26	1956						
Mud	Mud								33	25	1954
Mud	Mud								28	25	1956
Mud	Rush-grass	Over winter	52	44	1957	14	17	1954	21	22	1957
Mud	Rush-grass	Over winter				19	18	1955			

1/ Pintails, mallards, blue-winged teal, shovelers, gadwalls and baldpates.
2/ The average number of adult ducks per 1,000 yd. shoreline, expressed as a percentage of: Σ average adult ducks per 1,000 yd. shoreline on each of the study area's five subdivisions.
3/ Mainly Juncus balticus, Hordeum jubatum, and Carex spp.
4/ At least 18 in. of mud beyond shoreline vegetation; usually much wider expanses of mudflat.

TABLE 27.--USAGE OF THREE STUDY-AREA LAKES BY ADULT DIVERS 1/, FROM MAY TO MID-JULY, IN RELATION TO SHORELINE TYPE

Average Shoreline Type		Time of Water Level Change	Percentage Abundance 2/ Per Unit of Shoreline								
			Cz-Lake			D-Lake			Cy-Lake		
Spring	Previous Summer		Male	Female	Year	Male	Female	Year	Male	Female	Year
Rush-grass 3/	Rush grass		38	32	1955	28	30	1957			
Rush-grass	Mud 4/	Mid-August	32	28	1954	38	43	1956	24	24	1955
Rush-grass	Mud	September	36	33	1956						
Mud	Mud								14	14	1954
Mud	Mud								12	12	1956
Mud	Rush-grass	Over winter	36	34	1957	29	29	1954	28	26	1957
Mud	Rush-grass	Over winter				27	28	1955			

1/ Scaups, redheads and ruddy ducks.

2/ The average number of adult ducks per 1,000 yd. shoreline, expressed as a percentage of: Σ average adult ducks per 1,000 yd. shoreline on each of the study area's five subdivisions.

3/ Mainly Juncus balticus, Hordeum jubatum, and Carex spp.

4/ At least 18 in. of mud beyond shoreline vegetation; usually much wider expanses of mudflat.

immediate and dramatic. Numbers climbed from fewer than 50 to concentrations of 500-1,000. Stomachs of 18 ducks collected from these concentrations contained largely seeds of pondweeds.

What evidently had taken place was that as waters gradually receded, pondweeds (Fernald, 1932:11,18) and possibly other aquatics were stimulated to produce seed. With reflooding, the dry seeds floated to the surface and apparently constituted an attractive and readily available food for waterfowl.

Effect of Extensive Mudflats During June and July--The hypothesis that postbreeding drakes are chiefly drawn to impoundments by the presence of mudflats, was tested on D-area Lake. Water levels were purposely lowered here in October 1954, and held low until mid-August 1955, to create the desired mud-type shorelines. In 1954, 1956 and 1957, mud shorelines were absent after the beginning of June. During this latter group of years, average numbers of drakes per count from June 6 to 15 declined 23 percent, while in 1955 the average number increased 41 percent (Fig. 22). The importance of mudflats in attracting drakes was thus clearly demonstrated.

Effect of Partial Destruction of Shoreline Cattail--In view of the generally low utilization of A-area Potholes by breeding waterfowl, an experiment was conducted to assess the reaction of ducks to a partial destruction of cattail shorelines. A herbicide spray, consisting of a mixture of 2,4-D and Dalapon, was applied at a rate of 12.5 lb. (active ingredient) of 2,4-D and 10 lb. (active ingredient) of Dalapon per acre. Approximately 0.5 ac. of cattail

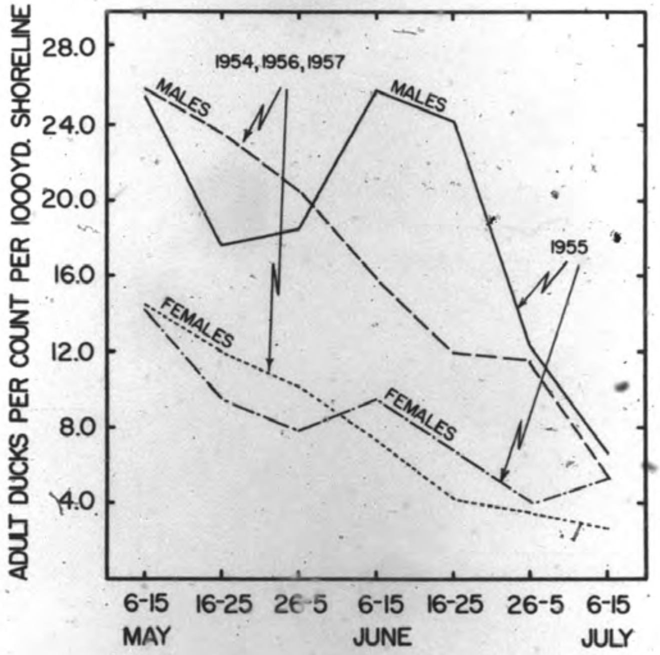

Fig. 22. Adult duck numbers on D-area Lake, extensive mudflats during June and July 1955, mudflats absent during June and July 1954, 1956, and 1957.

bordering three potholes was sprayed on August 15-16, 1955. The length of shoreline treated around each was: A_1--300 yd. (68 percent), A_5--225 yd. (58 percent), A_9--225 yd. (40 percent).

In the spring of 1956, prior to the initiation of growth, there was no apparent physical difference in the height or density of sprayed and unsprayed cattail stands. New growth began to appear on unsprayed sites about May 10, and by May 25 had attained an average height of 3 ft. Sprayed sections experienced little new growth throughout the entire summer; consequently nothing replaced the dead stalks of the foregoing year's stand when they rotted and toppled. After the third week of May, there was a vast difference in treated and untreated shorelines. Adult ducks of all species responded quickly to the above changes (Fig. 23). Numbers per 1,000 yd. of shoreline were alike during the period May 6-15. Usage of sprayed potholes increased to almost four times that of unsprayed potholes by May 26-June 5, as shoreline differences became more and more pronounced. This situation obtained until July 15 when counts ended.

The distinction between sprayed and unsprayed cattail shorelines was very marked in the spring of 1957 (Fig. 24). Cattail regenerated on sprayed sites in late May, June and July; and at the close of the summer herbicide-treated stands and untreated stands were similar once again. Unlike 1956, numbers of adult ducks per 1,000 yd. shoreline were not initially comparable on sprayed and unsprayed potholes (Fig. 23). Those with reduced cattail stands attracted about three times as many ducks. However, as shoreline differences slowly vanished, waterfowl distributions returned to normal.

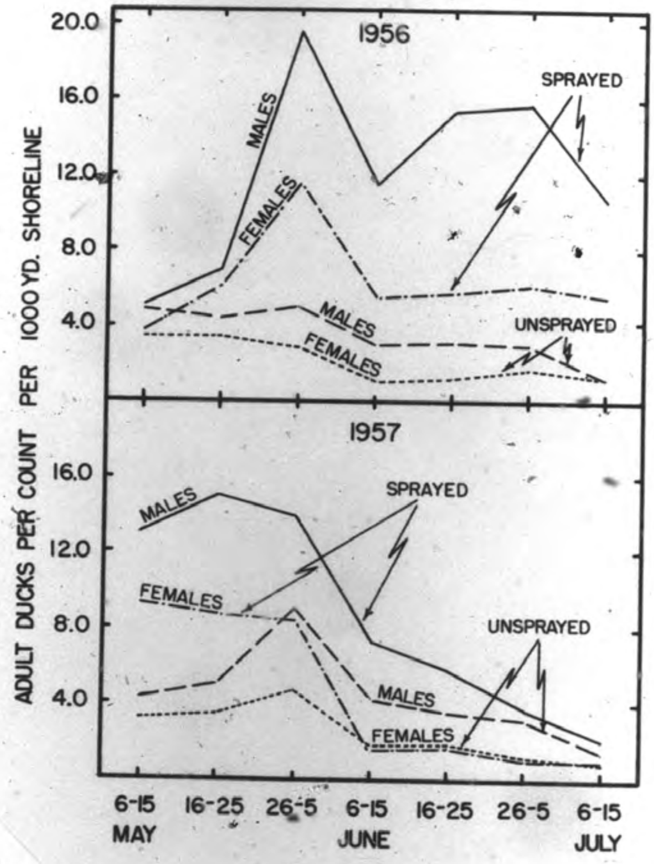

Fig. 23. Adult duck numbers on sprayed and unsprayed potholes in A-area, May to mid-July, 1956-57. Potholes sprayed to destroy part of cattail edge.

Fig. 24. Cattail-fringed pothole in A-area, early May 1957, before appearance of new growth; sparse stand along center and right shoreline--foreground and background--sprayed during August 1955 to remove cattail; dense stand to left not sprayed.

The reaction of ducks to partial removal dense cattail shorelines is probably attributable to one, or a combination, of the following factors: (1) the greater accessibility of shoreline loafing spots, (2) the desire of waterfowl for an unobstructed view of impoundment shorelines and adjacent terrain, (3) the increased accessibility of shoreline food plants, and (4) the increased abundance of submergent food plants. I am inclined to put most emphasis on the first two points.

Summary

During 1953-57, complete censuses of adult ducks were made on impoundments of the study area's five subdivisions. Counts were taken between 8 a.m. and 12 noon, from May to mid-July. Arrival dates, sex ratios, and species composition of the breeding population are given. Scaups and blue-winged teal comprised 50 percent of the waterfowl counted. The minimum mortality rate for drakes on the study area was 2 percent during May to mid-July, while the minimum mortality rate for hens was 8 percent over the same period. Adult population fluctuations on study-area subdivisions were caused primarily by (1) a movement of breeding pairs into pothole areas as nesting began, and later by (2) the concentration of postbreeding drakes on mudflat areas. The number of breeding pairs on censused impoundments varied from 112 in 1953 to 214 in 1957. An influx of both males and females occurred the latter half of May 1957, when most natural potholes in the region were drying up as a result of a spring drought. These birds apparently did not renest on the study area. Cattail-bordered potholes supported fewest breeding pairs per unit of shoreline. The blue-winged teal were least affected by differences in shoreline type. Spring waterfowl populations responded inconsistently or not at all to changes in shoreline type stemming from fluctuating water levels. Mid-August flooding of mudflats produced in spring and summer by slowly declining water levels, attracted large numbers of adults and flying juveniles. Partial removal of cattail shorelines surrounding three A-area Potholes evoked a marked increase in usage by adult ducks.

NESTING

The objectives of the nesting study were broadly: (1) to determine nest distribution and relative usage of various cover types, (2) to determine factors affecting nesting success, (3) to correlate spring weather and nesting phenology, and (4) to secure information on renesting for productivity calculations.

Methods

Nest Hunting--Dogs were utilized for nest hunting during this study with excellent results. The various breeds consisted of a weimaraner, a Brittany spaniel, a cocker spaniel, a Labrador-Alsatian cross and a Labrador-Chesapeake cross. These dogs discovered many nests before incubation had begun, and others we would surely have missed due to the hen's absence or refusal to flush. Moreover, they located a large number of terminated nests, i.e. nests that were hatched or destroyed, etc. before being found.

The usual procedure when nest hunting was for two men to work back and forth across an area, keeping 30-50 ft. apart; the dogs ranged ahead and in between. The likelihood of flushing birds was increased by rapping short pieces of lath together. Systematic searches were extended 300 yd. back from the shorelines of D-, Cz- and Cy-area Lakes. The ground covered (Fig. 25) comprised approximately 300 ac. of mixed-prairie community, 160 ac. of *Juncus* community, 30 ac. of halophytic growth and 20 ac. of cattail. Half of the cattail was emergent. The surface area of impoundments surrounded by this cover totalled about 170 ac.

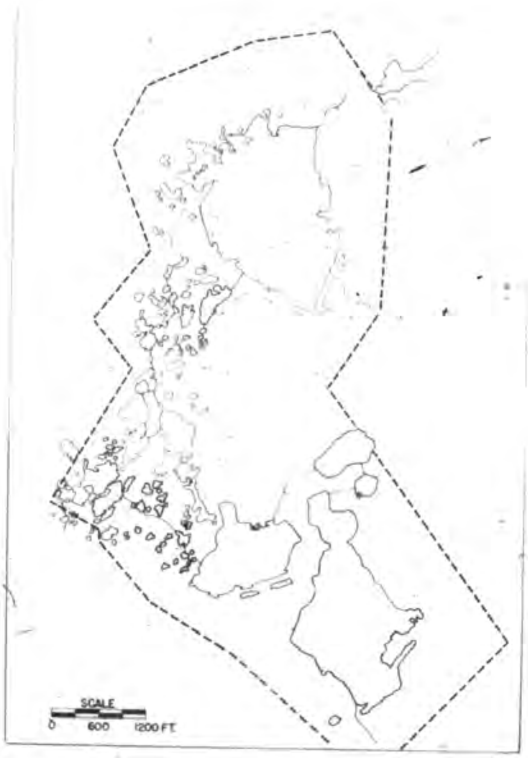

Fig. 25. Section of study area intensively searched for duck nests every 7-10 days.

A 43-ac. fenced area, 1 mi. south of the main study area, was also searched for nests. This fenced area contained only 3 shallow potholes that were often dry by mid-June, but one of its sides opened into a 23-ac. lake. The cover here was largely mixed-prairie community.

All terrain involved in the nesting study was thoroughly covered every 7-10 days, from early May to the end of July. Short stakes, placed 20 ft. away, were used to mark nest sites; locations were plotted on field maps. Care was taken to disturb the vegetation around each nest as little as possible. Down was always pulled over the eggs following examination.

Nest Data Recorded--Information kept on nests included: species, date found, number of eggs (initial and final), quantity of down, distance to nearest water, plants forming nest cover, concealment rating (very good, good, fair and poor), date of hatching or other fate, and number of eggs hatching.

Table 28, footnote 2 summarizes criteria for each of the four classes of nest concealment. During the final year of the study, nest concealment was rated as before; in addition, however, a General Electric type DW-68 photometer was used to measure light intensity on the floor of each nest in comparison to light intensity immediately above the impinging vegetation (Glover, 1956). After converting photometer readings to foot-candles, the percentage of light penetrating the nest cover was computed. Shadows cast by nest cover at various times of the day could have produced marked differences in nest-floor light readings. To avoid this, nest sites were completely

TABLE 28.--NEST CONCEALMENT RATING VS PERCENTAGE DIFFUSE LIGHT PENETRATION 1/

Nest Concealment Rating 2/	Mean Percentage Light Penetration	Approximate Range of Percentage Light Penetration	Percent of Nests Found in Designated Range
Very good (45)	24 ± 3 3/	7-35	82
Good (66)	52 ± 2	36-70	83
Fair (25)	80 ± 3	71-94	92
Poor (4)	96 ± 3	95-99	100

1/ The quantity of diffuse light (measured with nest site shaded) reaching the nest, expressed as a percentage of diffuse light immediately above the nest cover.

2/ Number of nests given in brackets. The following criteria were set up as a means of rating nest concealment: Very Good--hen and nest concealed from both sides and top. Good--hen and nest concealed from sides; little concealment from above. Fair--hen and nest only partially concealed from sides; no concealment from above. Poor--hen and nest with little or no concealment from sides; no concealment from above.

3/ 95% confidence limits.

shaded, and all measurements made in diffuse light only. Aside from being easily conducted and quantitative, the photometer method of describing nest concealment permits readings on a series of nests to be combined into a single statistic—average percentage light penetration value.

The possibility of substituting mean percentage light penetration values (Table 28, column 2) for concealment ratings (Table 28, column 1) on nests found prior to 1957 was explored. Percentage light penetration values (p.l.p. values) for the 1957 nests of three species of ducks were averaged, and compared with averages derived by substituting mean p.l.p. values for concealment ratings on these same nests (Table 29). I concluded that the resulting differences were sufficiently small to justify converting nest concealment ratings to mean p.l.p. values.

The problem of determining causes of nest destruction was simplified by the relative scarcity of crows, magpies, and mammalian predators other than skunks and coyotes. Characteristic types of egg-shell remnants and other sign (Sowls, 1948; Rearden, 1951) were helpful in designating nest predators. Because such techniques are only partly reliable, considerable nest destruction, including that probably inflicted by coyotes, was ascribed in the present study to unknown predators.

Embryos in uneaten eggs of predator-destroyed nests were aged to ascertain the stage at which destruction occurred, and also to provide dates of nest initiation.

TABLE 29.--RELATIONSHIP BETWEEN AVERAGE PERCENTAGE LIGHT PENETRATION VALUES OF NEST COVER AS COMPUTED BY TWO DIFFERENT METHODS

	Scaup (49)1/	B-w. Teal (28)	Mallard (23)
Av. of individually measured p.l.p. values	54.6	32.0	51.0
Av. of mean p.l.p. values substituted for concealment ratings	53.4	32.6	51.7
Difference	1.2	-0.6	-0.7

1/ Number of nests.

General Nest Data

In the following sections, all data refer to active nests unless otherwise specified.

Distance from Water--Mallards and green-winged teal were the dabblers that nested closest to water; pintails and gadwalls nested furthest away (Table 30). While lesser scaups usually nest on dry ground (Bent, 1923:219), it was surprising to find 50 percent of the redheads and ruddy ducks, and even 2 of 18 canvasbacks also nesting on land. Distributions of nests of the six most common land-nesters are plotted in Fig. 26.

Concealment--Nest concealment varied greatly between species (Table 30). Green-winged teal and blue-winged teal, the two smallest ducks, had the best concealed nests. In fact, with the exception of the pintail, there appeared to be a direct relationship between body size and degree of concealment among species nesting predominantly on land.

The pintail's habit of frequently nesting in the sparsest of cover is well known (Bent, 1923:146; Kalmbach, 1938; Milonski, 1958; and others). In 1954, 17 of 29 pintail nests were discovered on ground that had been completely denuded of vegetative cover by an April 13 prairie fire (Fig. 27). Some of these birds nested only a few feet from unburned areas with excellent cover. No other species used the burn for nesting. A similar situation existed later, where a fire occurred in the fall of 1955, on another tract of land 10 mi. south of the study area. The next spring, repeated searches of a 40-ac. block within this burn and surrounding some permanent impoundments yielded pintail nests only.

TABLE 30.--AVERAGE DISTANCE FROM WATER AND CONCEALMENT OF NESTS

Species (Number of Nests)	Average Distance to Water (Ft.)	Average Percentage Light Penetration of Nest Cover 1/
Canvasback (18)	0	78
Ruddy (15)	2	52
Redhead (21)	4	66
Scaup (198)	39 ± 10 2/	45
Mallard (135)	54 ± 16	54
Green-winged teal (22)	65 ± 37	32
Baldpate (23)	72 ± 31	47
Blue-winged teal (162)	74 ± 60	40
Shoveler (56)	97 ± 30	46
Gadwall (63)	123 ± 40	51
Pintail (97)	164 ± 59	69
White-winged scoter (3)	300	52

1/ The quantity of diffuse light (measured with nest site shaded) reaching the floor of the nest, expressed as a percentage of diffuse light immediately above the nest cover.

2/ 95% confidence limits.

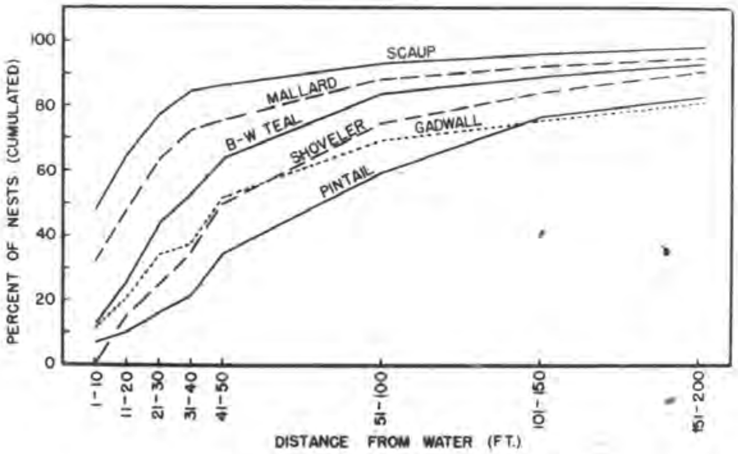

Fig. 26. Distribution of nests of six species in relation to nearest water; sample sizes given in Table 30.

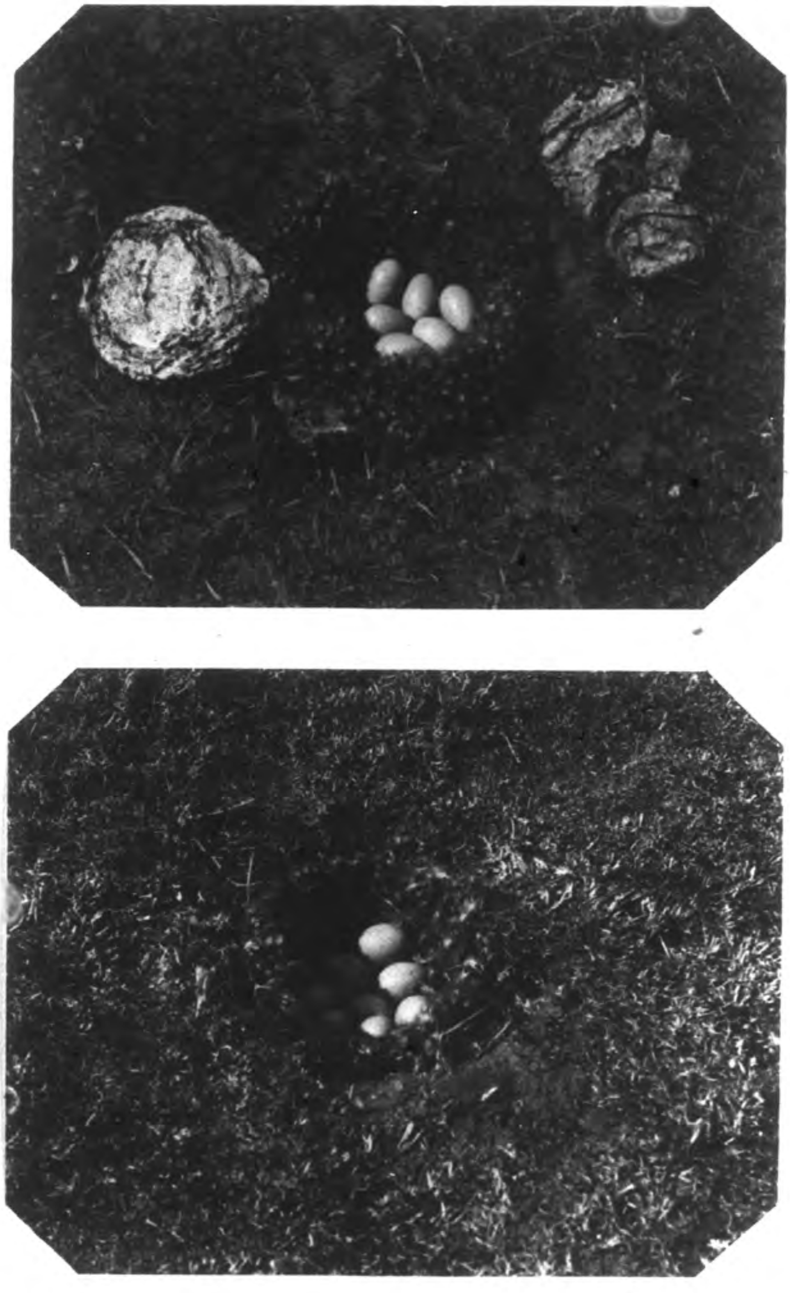

Fig. 27. Pintail nests placed on burned mixed-prairie community after cover was completely destroyed by fire.

Redhead nests on dry ground were often very poorly concealed, and the large quantities of white down that invariably became scattered around them was particularly conspicuous. Most canvasback nests over water were placed in open rather than dense stands of emergents. This is reflected in the high average p.l.p. value of 78 percent (Table 30).

<u>Clutch Sizes</u>--Four species averaged 10 or more eggs per nest (Table 31), viz. blue-winged teal--10.4, shoveler--10.1, redhead--10.1 and scaup--10.0. Mean clutch size was smallest in pintails (6.7 eggs) and ruddy ducks (7.1 eggs). Significant declines in average clutch size, over the nesting season, are shown (Table 31) for pintails, mallards, shovelers, blue-winged teal and scaups. A comparable shrinkage in the clutches of the first four species was demonstrated by Sowls (1955: 132), and Low (1945) had done this for the redhead.

<u>Viability of Eggs</u>--Nonviable eggs were classified as those which failed to hatch in successful nests, due to infertility or death of the embryo. In eight previous field studies (Low, 1945; Earl, 1950; Miller and Collins, 1954; Hunt and Nayler, 1955; Anderson, 1956, 1957; Steel <u>et al</u>., 1956; and Mendall, 1958) losses of this nature have averaged about 9 percent. In successfully hatched nests during the current study, 105 (7.3 percent) of 1,446 eggs were nonviable (Table 32); another 1.5 percent were lost to predators, etc.

<u>Hatching Periods</u>--Hatching periods (Fig. 28) were derived by back-dating 1953-57 aged broods according to the method of Blankenship <u>et al</u>. (1953). Both early and late hatches occurred during this time, and the span of hatching periods shown in Fig. 28 must be fairly near the maximum for each species. In the early-nesting pintail, 90 percent

TABLE 31.—CHANGES IN MEAN CLUTCH SIZE DURING NESTING SEASON 1/

Species	Mean Clutch Sizes Completed During Different Periods			Total
	Before May 16	May 16-31	After May 31	
Pintail (79) 2/	7.2 ± 0.4	6.2 ± 0.5	6.2 ± 0.6	6.7 ± 0.3
Mallard (97)	9.6 ± 0.5	8.9 ± 0.5	8.1 ± 0.4	8.8 ± 0.3
	Before June 1	June 1-15	After June 15	
Shoveler (45)	10.7 ± 0.4	10.0 ± 0.6	9.4 ± 0.6	10.1 ± 0.3
Blue-winged teal (114)	11.1 ± 0.3	10.5 ± 0.3	9.0 ± 0.6	10.4 ± 0.2
	Before June 16	June 16-30	After June 30	
Scaup (131)	10.6 ± 0.6	10.2 ± 0.2	8.5 ± 0.7	10.0 ± 0.3
Gadwall (55)	9.8	9.9	8.8	9.4 ± 0.4
Baldpate (20)				8.9 ± 0.8
Green-winged teal (18)				8.7 ± 0.7
Redhead (21)				10.1 ± 0.9
Canvasback (16)				8.0 ± 1.1
Ruddy (14)				7.1 ± 0.9

1/ 95% confidence limits are placed on mean clutch sizes of species whose clutches exhibited significant decreases as the season progressed, and on all average clutch sizes.

2/ Number of complete clutches.

TABLE 32.--NUMBERS OF EGGS HATCHING IN SUCCESSFUL NESTS 1/

	Number of Eggs Hatching	Infertile or Dead Embryo	Other Eggs Lost 2/	Total
Eggs	1,319	105	22	1,446
Percentage	91.2	7.3	1.5	100.0

1/ Includes nests of all species on the study area except white-winged scoters, none of whose three nests hatched.

2/ Disappeared, taken by predators or kicked from nests.

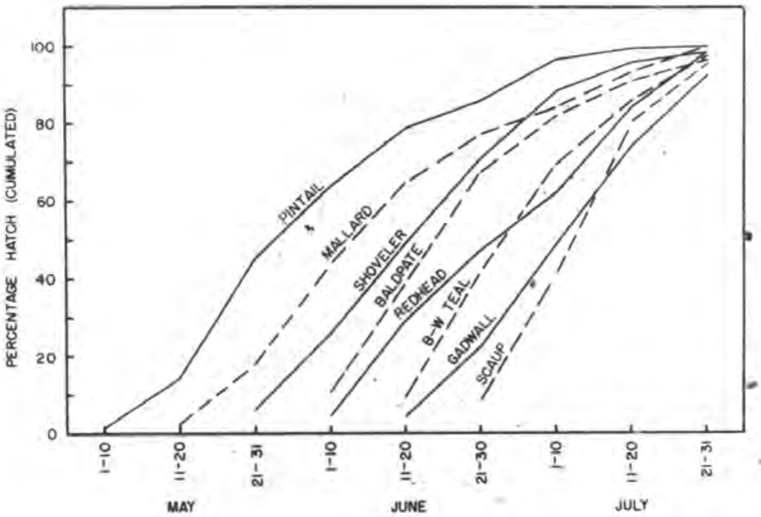

Fig. 28. Average span of the hatching period for eight species of ducks based on back-dating of aged broods, 1953-57. All hatching was completed by August 15. Brood sample sizes were: pintail--853, mallard--301, shoveler--693, baldpate--323, redhead--225, blue-winged teal--1,249, gadwall--394, scaup--510.

of the hatch took place over approximately 65 ys; in the late-nesting scaup, 90 percent of the hatch was restricted to about 25 days.

Limited data did not permit the inclusion of the canvasbacks, green-winged teal, white-winged scoters and ruddy ducks, in Fig. 28. Canvasback and shoveler broods usually appeared about the same time, and green-winged teal and blue-winged teal were close together. White-winged scoters and ruddy ducks were slightly later than scaups.

Nesting Cover

Effect of Cattle on Nesting Cover--Marked differences in density of cover existed between the Juncus and mixed-prairie communities (Table 33). Comparing data in Table 33 with concealment ratings given in Table 28, we may say that on the average the Juncus community offered good concealment for nests, and the mixed-prairie community fair conc lment. Lesser differences occurred between grazed and ungrazed sections within each community.

Since cattle were held on another part of the lease until the first week of July, quadrats examined in early May, June and July, showed mainly the effect of the previous season's grazing. The differences in grazed and ungrazed quadrats on mixed prairie amounted to an average p.l.p. value of 8 percent in 1955, and 9 percent in 1956. Nesting cover on mixed prairie that had been burned during April 1954 was poorer the following year than on unburned sites. Juncus community nesting cover also decreased when unprotected from cattle (Table 33). This is indicated by the 12 percent difference

TABLE 33.--EFFECT OF CATTLE ON NESTING COVER IN THE MIXED-PRAIRIE AND JUNCUS COMMUNITIES 1/

Cover Type	Average Percentage Light Penetration 2/	
	1955	1956
Mixed prairie		
Grazed 3/	89 (60) 4/	89 (120)
Ungrazed	81 (60)	80 (120)
Difference	8	9
Mixed prairie 5/		
Grazed	96 (60)	
Ungrazed	88 (60)	
Difference	8	
Juncus		
Grazed	52 (60)	
Ungrazed	40 (60)	
Difference	12	

1/ See Appendix for sampling methods.
2/ The quantity of diffuse light reaching the ground, expressed as a percentage of diffuse light immediately above the vegetative cover.
3/ Average grazing pressure throughout the study--1.2 ac./head/mo. (excluding calves) over the 5-mo. period, July-November.
4/ Number of quadrats examined.
5/ Burned in spring 1954.

in average p.l.p. values from grazed and ungrazed quadrats. As mentioned earlier in discussing the Juncus community, it was chiefly trampling not grazing that affected J. balticus.

I interpret the above data as showing that grazing (1.2 ac. per head per month, July-November) did not seriously reduce nesting cover.

The presence of Calamovilfa longifolia, a relatively unpalatable grass, has helped to maintain the quality of nesting cover in the mixed-prairie community. It provided the primary cover for 67 percent of the nests found here. From what I have seen of this species' ability to withstand heavy grazing around salt licks and stock-watering places, I suspect that it would persist in adequate stands for nesting even with overgrazing. In that regard, it resembled Spartina pectinata, Hordeum jubatum, and Cirsium arvense at Delta, Manitoba (Sowls, 1955:69), and Symphoricarpos occidentalis in the Caron Potholes of Saskatchewan (Leitch, 1951).

Grazing occurred on the study area at a time when Calamovilfa was most unpalatable to livestock. Hence, a shift in range management that would institute spring and/or winter grazing might prove detrimental. On the section of the lease lying south of the study area, cattle grazed through April, May and June; and nesting cover, at least superficially, appeared to be poorer.

Probably the greatest danger to nesting cover is not grazing alone, but the combination of grazing and prolonged drought.

Some grasses in the halophytic communities were even more unpalatable than Calamovilfa. This was especially true of Hordeum jubatum and Spartina gracilis after anthesis. On the whole, nesting cover afforded by grass-type halophytic communities was superior to that of the mixed-prairie community.

The importance of grazing and trampling in preventing cattail establishment, and the temporary devastation of A-area's cattail stand in late fall 1953, have already been described. Generally speaking, cattail as an established emergent is little affected by cattle, but as a moist-soil stand it is often badly trampled. On the treeless plains, livestock frequently seek shade and relief from flies in cattail cover.

Cattle prevented the growth of willows and aspen where conditions were otherwise favorable. Such trees were of little consequence as waterfowl nesting cover, but were attractive to nest-robbing crows and magpies. In A-area, fenced since the fall of 1947, a parkland-like habitat has developed (see Fig. 12). The first crow's nest was built there in 1955, and another appeared in 1956. The first magpies observed on the study area nested in A-area during 1957, utilizing the crow's nest of the year before as a foundation for their own bulky structure.

Usage of Various Cover Types--On the basis of cover-type selection for nesting, ducks fell into four groups (Table 34): (1) those nesting predominantly in the Juncus community--scaups, mallards, green-winged teal and baldpates; (2) those nesting about half the time in Juncus community and half in the mixed-prairie community--blue-winged teal, pintails and shovelers; (3) gadwalls, nesting mainly in Juncus,

TABLE 34.--USAGE OF COVER TYPES BY VARIOUS SPECIES OF DUCKS

Species	Percentage Frequency of Nests in Cover Types					
	Cattail (65)1/	Juncus (496)	Halo-phytic (41)	Mixed Prairie (153)	Burn2/ (17)	Weed (30)
Scaup (194) 1/	1	86	5	6		3
Mallard (136)	17	70	1	11		1
Green-winged teal (22)	5	86		9		
Baldpate (21)		81		14		5
Blue-winged teal (163)	1	51	10	36		2
Pintail (96)	2	42	3	35	18	
Shoveler (51)		41	16	43		
Gadwall (64)		58	3	13		27
Redhead (21)	57	43				
Canvasback (19)	89	5	5			
Ruddy (15)	47	53				
Av. % frequency	8	62	5	19	2	4

1/ Number of nests.
2/ A portion of the mixed-prairie cover type that was burned during April, 1954.

but also using weedy cover to a considerable extent; and (4) redheads, canvasbacks and ruddy ducks that used cattail much more than did other waterfowl. Sixty-two percent of all nests were placed in *Juncus*, 19 percent in mixed-prairie, 8 percent in cattail, and 5 percent in halophytic cover types. Highest nest densities were in cattail and in *Juncus*. The average density, including terminated nests, was 2.6 ac. per nest (Table 35).

Pintails alone nested on recent burns. Where pintails were absent in Iowa, Glover (1956) reported that he found no duck nests on burned areas. The common usage of weedy cover by gadwalls, noted above, was also pointed out by Williams and Marshall (1938) at Bear River, Utah.

Two important factors affecting use of terrestrial cover types on the study area were concealment value and proximity to water. The average p.l.p. value at nest sites in *Juncus* cover was 48 percent; and in mixed-prairie cover this value was 50 percent. One hundred and twenty *Juncus* community quadrats had an average p.l.p. value of 46 percent, while 660 mixed-prairie community quadrats averaged 85 percent. It is obvious that despite the pronounced difference in average concealment value of these two cover types, ducks selected vegetation within each that provided roughly the same degree of concealment. Inasmuch as the preferred concealment was closest to that available in the *Juncus* community, it was not surprising to find greater nest densities there.

Girard (1941) regarded quality as the important factor in the mallard's selection of nesting cover. Others have likewise re-

TABLE 35.—AVERAGE DENSITY OF NESTS IN DIFFERENT COVER TYPES ON THE WILL J. REID STUDY AREA

	Cover Type				
	Cattail	Juncus	Halo-phytic	Mixed Prairie Burn and Weed	Total 1/
Total nests (5 yr.)	64	480	38	171	994
Av. nests/yr.	12.8	96.0	7.6	34.2	198.8
Av. ac./yr.	20	160	30	300	510
Av. ac./nest/yr.	1.6	1.7	3.9	8.8	2.6

1/ All nests found, both active and terminated.

ported highest nest densities where cover was heaviest (Bue et al., 1952; Sowls, 1955:67; Glover, 1956; and others).

Eighty-three percent of all duck nests were within 100 ft. of the water's edge. Nest densities in cattail and Juncus were more than twice those in halophytic cover, and five times those in the combined mixed-prairie, burn and weed cover (Table 35). However, within the first 25 ft. from water, nest densities in halophytic, mixed-prairie, burn and weed cover averaged about the same as in cattail and Juncus (see Table 44). While some of the increased nesting in the former grouping may reflect heavier growth due to improved moisture conditions, this is certainly not the complete explanation. Undoubtedly the proximity-to-water factor is also involved.

Relative Usage of Old and New Cover for Nesting--There is a close relationship between earliness of nesting and relative importance of the previous year's vegetation as nesting cover (Table 36). Approximately 85 percent of the nest cover for pintails and mallards consisted mainly of old growth, while 88 percent of the nest cover for scaups was primarily new growth. In the over-all picture, waterfowl usage of old and new cover was about equal.

Selection of Plant Species for Nesting Cover--The mixed-prairie community contains a number of species capable of providing concealment for nests. To determine whether some tended to be selected or avoided by waterfowl, species occurrence in 660 quadrats was compared to species occurrence at 150 actual nest sites (Table 37). Only for Carex and Rosa did percentage occurrence differ significantly between quadrats and nests. Ducks apparently shunned Carex for nesting but

TABLE 36.--RELATIVE USAGE OF OLD AND NEW GROWTH FOR NESTING COVER

Species	Percentage of Nests in Different Cover				Average Date 50% Clutches Started
	All Old Growth	Mostly Old, Some New Growth	Mostly New Some Old Growth	All New Growth	
Pintail (88) 1/	64	20	8	8	April 29
Mallard (109)	62	24	9	5	May 9
Blue-winged teal (135)	36	29	23	13	May 28
Shoveler (41)	24	41	15	20	May 15
Gadwall (55)	5	22	24	49	June 4
Scaup (160)	1	12	59	29	June 6

1/ Number of nests.

TABLE 37.--RELATIVE FREQUENCY OF SPECIES PROVIDING PRIMARY NEST COVER IN MIXED-PRAIRIE QUADRATS COMPARED TO RELATIVE FREQUENCY AS PRIMARY NEST COVER AT ACTUAL NEST SITES

Plant Species	Percentage Occurrence	
	Primary Nesting Cover in 660 Quadrats 1/	Primary Nest Cover at 150 Nests
Calamovilfa longifolia	60	67
Carex spp.	14	3 2/
Stipa comata	9	4
Thermopsis rhombifolia	5	6
Artemisia spp.	3	3
Koeleria cristata	3	1
Agropyron smithii	2	7
Bouteloua gracilis	2	0
Agrostis scabra	1	1
Rosa spp.	1	6 2/
Poa spp.	0	1

1/ See Appendix for sampling methods.
2/ Statistically significant difference beyond 95% level.

deliberately sought out Rosa. Viewed through human eyes, the selection of rose bushes for nest cover appears reasonable, but the avoidance of sedges much less so.

Effect of Weather on Nesting

Dates of Nest Initiation--Nest initiation dates may be secured through nesting studies or brood counts. Nesting studies can, by embryo aging and by allowing for a laying rate of one egg per day, most accurately delineate the onset of nesting. Yet, there is always considerable time and trouble required to locate nests, and sample sizes are often small. The simultaneous counting and aging of broods provides large sample sizes, but as pointed out by Sowls (1955:82), these broods represent only successful clutches and thus apparent peaks of laying may be biased through renesting.

I decided to use brood data, and to attempt to remove any serious "renesting bias." No widespread or catastrophic nest destruction occurred; rather, nests were lost over the season through gradually intensified predation. Hence, broods representing first nesting attempts were always present in the brood-count data. The problem was to arrive at a method whereby average dates of nest initiation for each species would be based largely, if not entirely, on the back dating of such broods. I eventually selected the mean date of initiation of the first 50 percent of successful clutches, as determined by back dating the first 50 percent of the broods that were hatched (Table 38). This procedure was used only during years when brood counts for a species totalled 40 or more.

TABLE 38.—MEAN DATES OF INITIATION OF FIRST 50 PERCENT OF SUCCESSFUL CLUTCHES 1/

Year	Pintail	Mallard	Shoveler	Baldpate	Redhead	B-w.Teal	Gadwall	Scaup	Time Span 2/ (Days)
1957	Apr 13	Apr 20	Apr 24	May 1	May 7	May 17	May 21	May 27	44
1956	Apr 18	—	May 3	May 8	May 15	May 21	May 20	May 28	40
1955	Apr 15	Apr 27	May 8	May 15	—	May 19	May 30	May 30	45
1954	Apr 26	May 5	May 11	May 20	May 26	May 23	Jun 3	Jun 3	38
1953	May 6	—	May 18	May 13	—	May 28	Jun 5	Jun 7	32

1/ Based on counts of 40 or more brood subclasses per year for each species.
2/ Difference in mean date of initiation of pintail and scaup clutches.

Mean dates of clutch initiation for eight species of ducks varied considerably from 1953 to 1957 (Table 38). In general, nesting appears to have become progressively earlier. The trend is summarized for each species in Table 39 and is fairly consistent. Taking 1957 as the earliest year, the preceding years were later than 1957 to the following extent: 1956—4.7 days; 1955--7.3 days; 1954--13.6 days; 1953—16.0 days. Differences between average nest initiation dates for pintails and scaups (the earliest and latest nesting species) tended to be somewhat less in late years than in early years. In other words, during late years the nesting season was slightly compressed.

Effect of Weather on Nest Initiation--The meteorological conditions responsible for year to year variations in the breeding phenology of waterfowl are only vaguely understood. Low (1945) speaking of redheads in Iowa, declared: "The dates of nest construction followed the first warm weather late in April and early in May." Mendall (1958:80) indicated that a similar correlation existed for the ring-necked duck in Maine, and stated that "Long periods of cold or precipitation will delay nesting, while several days of unusually high temperatures, particularly if these are accompanied by sunshine, will bring the onset of nesting at earlier than average dates." At Delta, Manitoba, Sowls (1955:84-87) noted a 2-week delay in mallard and pintail egg laying during 1950 as compared to 1949, and pointed out that the April 15-May 30 mean temperature in 1950 was 7 F. lower than the previous year. He also observed that on cold evenings there was less courtship activity and that fewer pairs were observed seeking

TABLE 39.—YEARLY DIFFERENCES BETWEEN MEAN INITIATION DATES OF THE FIRST 50 PERCENT OF SUCCESSFUL CLUTCHES 1/ (1957 TAKEN AS BASE OR EARLIEST YEAR)

Year	Difference in Days								
	Pintail	Mallard	Shoveler	Baldpate	Redhead	B-w.Teal	Gadwall	Scaup	Av.
1957	0	0	0	0	0	0	0	0	0.0
1956	5 2/	-	9	7	8	4	-1	1	4.7
1955	2	7	14	14	-	2	9	3	7.3
1954	13	15	17	19	19	6	13	7	13.6
1953	23	-	24	12	-	11	15	11	16.0

1/ Derived from dates given in Table .
2/ Number of days later than 1957.

nest sites. Sowls concluded that "apparently there is a temperature threshold just above freezing where [reproductive] activity stops."

Temperature and rainfall data were available for Brooks, Alberta, 26 mi. southwest of the study area. I attempted to correlate the progressively earlier nesting from 1953 to 1957 (Table 39) with maximum, minimum and mean temperatures, and with precipitation. In summary, I found no consistent relationship between nesting phenology and any of the above meteorological factors. However, April and May of the earliest year (1957) were characterized by higher mean temperatures and lower precipitation than occurred in the latest year (1953); and 1955, a year of intermediate temperatures and precipitation, was also intermediate as regards time of nest initiation (Fig. 29). Both 1954 and 1956 had subfreezing mean temperatures during the last week of April, yet egg laying in 1956 was begun on the average 9 days sooner than in 1954.

The only climatic factor that gave a highly significant correlation coefficient ($r = -0.99$) was a heat-sum taken each year from April 10 to 28 inclusive. This was correlated with relative-earliness-of-nesting data shown in the final column of Table 39. The heat-sum approach, i.e. the summing of degrees above freezing attained by daily maximum temperatures over a specific period, was used by Kluyver (1952) for the great tit (*Parus major*), a nonmigratory European passerine. He reported a significant correlation between heat-sums begun on March 16 and initiation of laying by this species.

Despite the high correlation between April 10-28 heat-sums and nest initiation data, I am not convinced that there is a real

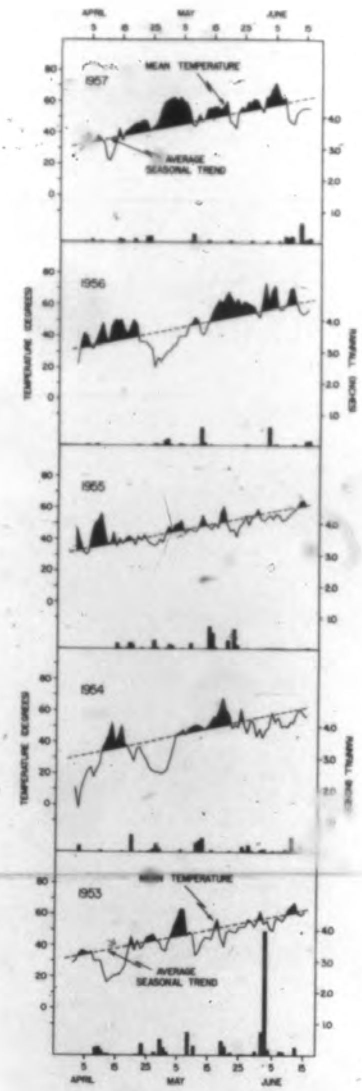

Fig. 29. Temperature and rainfall data for Brooks, Alberta (Dept. of Transport, Toronto).

association between the two phenomena. The later migrants--blue-winged teal, scaups and gadwalls--often do not arrive in the region of the study area until mid-April or later, and pintails and mallards regularly begin to nest before the April 10-28 period has elapsed.

Effect of Weather During Laying and Incubation--The effect of low temperature and rainfall per se on the fate of partially completed and/or incubated clutches is not well known. Yocum (1950) said that in Washington during the spring of 1948, below normal temperatures and above normal precipitation were recorded, and that hatching peaks were about 2 weeks behind those of 1947 and 1949. He seems to attribute this primarily to flooding, however. Sowls (1955:89) found no evidence of losses of wild duck eggs by freezing in Manitoba. He also pointed to experiments on chicken-egg hatchability which disclosed that eggs could withstand considerable cold. An example of the effect of cold and snow on mallard nesting in Saskatchewan was reported by Gollop (1954): "That the [illegible] 10-11 snowstorm and cold weather did not adversely affect mallard production is indicated in the following mallard data. . . . Of 17 nests begun before the storm, 15 (88 percent) were still being incubated after it; . . . The other two clutches were fresh when found before the storm and may have been deserted because of the storm or disturbance by the workers. Twelve of these 15 nests eventually hatched, the other three apparently being lost to predators." In Manitoba, Kiel (1954) stated: "Mallard nest histories showed that nests active during the period of sub-freezing temperatures and snow, May 11-16, were as successful as nests started after May 16. A disproportionate number of mallard nests in the egg-laying stage at the time of heavy rains, May 24–June 3, were unsuccessful." Mendall (1958:94-95) believed that the eggs of ring-necked ducks can withstand considerable moisture and chilling without destroying their viability. He noted that when temperatures approached freezing, or during rains, ring-necks incubated very closely.

Data collected in the present investigation strongly suggest that neither low temperatures, snow, nor extremely heavy rainfall adversely affected nesting. In 1954, the mean date of initiation of 50 percent of successful pintail clutches was April 26 (Table 38); from April 23 to May 1 there were 5 in. of snow, the daily mean temperature averaged 23°F. and overnight lows fell to 12°F. In 1956, the mean date of initiation of 50 percent of successful pintail clutches was April 15; between April 25 and May 1 snowfall totalled 4.5 in., daily means averaged 27°F. and minimum temperatures reached 14°F. Temperatures during May 11-14, 1953, dropped to the mid-20's overnight in the wake of a May 10 blizzard that left 2.8 in. of snow on the ground. I had no evidence that pintails and mallards deserted because of such weather, and this period corresponded to the initiation of laying among baldpates (Table 38).

On June 1, 2 and 3, 1953, a near record rain of 4.89 in. occurred (Fig. 29). While 4 nests were lost at that time due to flooding, there was not a single case of desertion among the 35 other nests in various stages of laying and incubation that were under observation.

Predation on Nests

Few studies in recent years have failed to show that predators were the chief cause of nest loss. The present one was no exception, and in the sections which follow, the various factors affecting predation are considered.

Avian Predators--Crows and magpies are much less numerous on the mixed prairie than in adjoining parklands. Nevertheless, where trees line natural water courses and irrigation canals, crows and magpies are very common. The crow's adaptability is well illustrated by its frequent use of railroad snowfences as nesting sites on the treeless plains.

Generally, crows made only irregular visits to the study area during spring and summer. A single pair nested in the willows of A-area in 1955 and 1956 but vanished by early June of both years. My observations on the feeding habits of these birds, plus the contents of a single stomach, indicated that toads (*Bufo haemiophrys*) constituted their main diet. The swarms of toads were almost past belief, and I cannot help feeling that in such prodigious numbers they were an important buffer against intensive egg hunting by the crows. Magpies first appeared on the study area in May, 1957; a pair raised a brood and remained all summer. California and ring-billed gulls were most common in 1953 and relatively uncommon thereafter. Nest destruction by all avian predators averaged only 2 percent.

Nest Destruction and Numbers of Mammalian Predators--The chief mammalian nest predator was the striped skunk. As an index to the abundance of predatory mammals from year to year, all observations of skunks, coyotes, badgers and weasels were recorded (Table 40). Differences in activity patterns, conspicuousness, etc. make comparisons of numbers between species hard to appraise; but major species fluctuations do, I believe, reflect changing population levels.

The high percentage of nests destroyed by skunks prompted me to conduct a limited control program, to see if hatching success could not be improved by lowering the skunk population. Where skunks have been reduced on some waterfowl breeding areas in the past, hatching success has risen (Kalmbach, 1938; Anderson, 1957). Henry (1939) declared: "In the Lower Souris marsh skunks readily become overabundant and are persistent destroyers of duck nests. The amount of damage may be reduced in direct proportion to the degree of control of the skunk population."

Accordingly, in 1955 and 1956, 50 chicken eggs were injected with several cubic centimeters of a phosphorous-base rat poison and placed well inside known skunk dens. It is difficult to evaluate how much of the later decrease (Table 40) in the skunk population may be attributed to this poisoning. Only one skunk was definitely known to have been so killed; it dwelt beneath our living quarters and was discovered when the building was moved in June 1955. Other skunks may have died in their dens and remained undetected, for none of the dens were excavated.

The best correlation between numbers of predators seen and percentage of nest predation is obtained with combined skunk and coyote data. The relationship of skunk numbers to percentage

TABLE 40.—SUMMARY OF MAMMALIAN PREDATORS OBSERVED ON OR WITHIN 1 MILE OF STUDY AREA AND PREDATION ON DUCK NESTS 1/

Mammalian Predators	Numbers of Mammalian Predators					
	1953	1954	1955	1956	1957	Total
Skunk	12	6	10	2	1	31
Coyote	6	6	12	13	4	41
Badger		3	1	1		5
Weasel	1					1
Total	19	15	23	16	5	78
% Nest pred.	73.9 ± 8.2 2/	60 ± 8	70 ± 7	69 ± 8	57.0 ± 8.6	

1/ Includes only hatched and predator-destroyed nests, and excludes those on mammal-free islands.

2/ 95% confidence limits carried to one decimal place in order to show significant difference between 1953 and 1957 in nest predation.

predation was good, except in 1956, when nest losses remained high in spite of an apparent population decline. Coyotes were very numerous that year. Weasels killed approximately 3 percent of nesting hens during the study.

The term "mammal-free island," used in this paper, refers to islands in D- and Cy-area Lakes, during years when they were separated from the main shoreline by water 18 in. or deeper. Channel widths ranged from 20 ft. to 150 ft. Hammond and Mann (1956) indicated that skunks are not barred by deep channels 20 ft. in width, and Sooter (1946) reported coyotes swimming to islands. I found no evidence (i.e. scats or destroyed nests), however, that either of these species reached the islands on the study area.

Relationship of Predation on Nests to Time of Season—Decreased nest losses in the latter half of the season have been noted by several investigators (Phillips, 1928; Kalmbach, 1937, 1938; and Hammond, 1940). With one exception, the crow was the main predator, and lower predation on later nests was ascribed to seasonal changes in its feeding habits. At the Lower Souris Refuge, skunks replaced crows as the number-one nest predator, and Kalmbach (1938) found that here too predation was lower and nesting success higher in the latter part of the season.

The reverse of the above picture was obtained on my study area (Table 41), where the predation rate climbed steadily through the nesting period. I believe the explanation here is simply that as the season progressed, more and more skunks left their dens and

TABLE 41.--RELATIONSHIP OF PREDATION ON NESTS TO TIME OF SEASON 1/

	Date Nest Begun			
	Before May 16	May 16-31	June 1-15	After June 15
Number of nests	95	123	120	88
Number destroyed	47	75	79	62
% Predation loss	49 ± 10	61 ± 9	66 ± 8	70 ± 10

1/ Includes only hatched and predator-destroyed nests.

began to wander about in search of food. With greater numbers of skunks at large, a higher proportion of nests were found and destroyed. I suspect the same condition prevailed apropos of nest destruction by coyotes.

Mendall (1958:113) described a similar situation in Maine, regarding nest losses to mink. Sowls (1958:123) stated that Franklin-ground-squirrel damage on the Delta Marsh in Manitoba was lowest early in the season because of (1) the presence of water barriers, and (2) the increased movements of ground squirrels later on.

Relation of Predation on Nests to Stage of Nesting--There was no indication that vulnerability of nests to predation varied from the onset of laying to the time of hatching (Table 42). Hammond (1940) said that studies on the Lower Souris Refuge showed highest nest losses during the laying period. Mendall (1958:112) believed that the first and last stages were most critical, and suggested that perhaps during hatching the noise of the chipping process attracted predatory mammals. While this did not appear to be a significant factor in the current study, I did note the following incident.

On July 28, 1953, I flushed a marsh hawk from the edge of an eared grebe's nest, situated in a small pothole. The female grebe was swimming nearby and was obviously distressed. An inspection of the nest disclosed the blood smeared remains of two freshly destroyed eggs, and a third in which all but the head of the chick was eaten. The fourth and last egg in the nest was just hatching and had not yet been touched. The aspect that impressed me most at the time was the high pitched sound, audible for at least 10 ft., eminating from the

TABLE 42.—RELATIONSHIP OF PREDATION ON NESTS TO STAGE OF NESTING 1/

Period After Initiation of Laying (Days)	No. of Nests Under Observation	Average Percentage Predation
1-12	146	44 ± 8
13-24	340	51 ± 5
25-36	283	49 ± 6

1/ Includes only hatched and predator-destroyed nests.

hatching egg. It is likely that the hawk had been initially attracted by this noise.

Relationship of Predation on Nests to Terrestrial Cover Type--Predation on nests differed sharply between various terrestrial cover types (Table 43). Predation was highest in Juncus and cattail cover, and lowest in mixed-prairie, halophytic, burn and weed cover. Average nest losses were 72 percent in Juncus and 56 percent in mixed-prairie cover. Since relative usage of cover types was not the same for all species of ducks, nests of some suffered higher predation. Mallards and scaups placed about 80 percent of their nests in the Juncus cover type and total losses to predators averaged almost 80 percent. In contrast, pintails, shovelers and blue-winged teal, placed 40-48 percent of their nests in Juncus cover and total losses averaged only 54-58 percent.

In probing for causes of the dissimilarity of predation rates in Juncus and cattail as compared to other cover types, I investigated the relationship of predation to distance from water (Table 44). Distance from water was apparently of no importance in the group consisting of mixed-prairie, halophytic, burn and weed cover types, but in Juncus-cattail cover, predation decreased significantly from 80 percent within the first 25 ft. of water, to 65 percent thereafter.

Had nest densities, 1-25 ft. from water in the Juncus-cattail cover, been appreciably higher than within the same zone in other cover types, one might have expected a correspondingly higher predation rate. This, however, was not the case (Table 45).

TABLE 43.--RELATIONSHIP OF PREDATION ON NESTS TO TERRESTRIAL COVER TYPE 1/

Species	Percentage Frequency of Nests in Cover Types						Average Percentage Predation
	Cattail (11) 2/	Juncus (368)	Halophytic (39)	Mixed Prairie (133)	Burn 3/ (17)	Weed (22)	
Mallard (101) 2/	8	78	1	12		1	79±8 4/
Scaup (157)	1	84	6	6		3	78±6
Gadwall (55)		60	4	13		24	64±13
Pintail (91)	1	42	3	35	19		58±10
Shoveler (45)		40	18	42			56±15
Blue-winged teal (141)	—	48	11	38		3	54±8
Av. percentage predation	91	72±4	56	56±8	53	50	

1/ Includes only hatched and predator-destroyed nests, and excludes those on mammal-free islands.
2/ Number of nests.
3/ A portion of the mixed-prairie cover type that was burned during April, 1954.
4/ 95% confidence limits.

TABLE 44.--RELATIONSHIP OF PREDATION ON NESTS WITHIN COVER TYPES TO DISTANCE FROM WATER 1/

Cover Type	% Frequency of Nests at Different Distances (in ft.) from Water		
	1-25	26-100	100
Juncus and cattail	49 (184) 2/	42 (161)	9 (34)
Percentage predation	80 (80±6)	66 (65±7)	59
Mixed prairie, burn halophytic and weeds	16 (33)	46 (97)	38 (81)
Percentage predation	52 (52±17)	55 (54±7)	54

1/ Includes only hatched and predator-destroyed nests of the following species: mallard, scaup, gadwall, blue-winged teal, pintail and shoveler. Excludes nests on mammal-free islands.

2/ Number of nests.

TABLE 45.—RELATIONSHIP OF NEST DENSITY IN COVER TYPES TO DISTANCE FROM WATER 1/

Cover Type		Distance (in ft.) from Water		Total
		1-25	25-	
Juncus and cattail	Total nests (5 yr.)	184	195	380
	Av. nests/yr.	36.8	39.0	76.0
	Av. ac./yr.	30	140	170
	Av. ac./nest/yr.	0.8	3.6	2.2
Mixed prairie, burn, halophytic and weeds	Total nests (5 yr.)	33	178	211
	Av. nests/yr.	6.6	35.6	42.2
	Av. ac./yr.	6	324	330
	Av. ac./nest/yr.	0.9	9.1	7.8

1/ Includes only hatched and predator-destroyed nests of the following species: mallard, scaup, pintail, blue-winged teal, shoveler, and gadwall. Excludes nests on mammal-free islands.

The concealment of hatched and destroyed nests within cover types, and at varying distances from water, was next calculated (Table 46). No marked differences were noted in average p.l.p. values that could be related to predation, either between cover types or between hatched and destroyed nests within cover types. Destroyed nests in cattail and Juncus cover had slightly better concealment than hatched nests. Many previous workers have reported that nest concealment had little or no bearing on nest losses to predators.

In summary, nest losses were unassociated with distance from water in the mixed-prairie, halophytic, burn and weed groupings of cover types. Nest losses within the first 25 ft. of water were significantly greater in Juncus-cattail cover than beyond 25 ft.; these losses were also significantly greater than in the previously mentioned group of cover types. Such differences were apparently unrelated to nest densities and to nest concealment.

The reason for this increased predation in the 1-25 ft. zone, probably then, rests with the feeding behavior and/or movements of the principal nest predator—the skunk. Two possibilities suggest themselves: viz. (1) skunks may be attracted to Juncus and cattail cover because vegetation there is densest and they can search for food unseen, or because other foods aside from duck eggs (frogs, snakes, invertebrates, etc.) are more abundant; and (2) skunks may simply discover more nests in this zone because its usually damp conditions make nest odors easier to detect.

TABLE 46.—RELATIONSHIP OF CONCEALMENT OF HATCHED AND DESTROYED NESTS 1/ TO DISTANCES FROM WATER

Cover Type	Nest Fate	Av. Concealment 2/ of Nests at Different Distances (in ft.) from Water			Average
		1-25	26-100	100	
Juncus and cattail	Hatched	50 (36) 3/	52 (54)	56 (14)	52
	Destroyed	45 (148)	48 (107)	55 (20)	47
	Difference	5	4	1	5
Mixed prairie, burn halophytic and weeds	Hatched	42 (12)	53 (44)	56 (37)	53
	Destroyed	45 (21)	52 (53)	58 (44)	53
	Difference	-3	1	-2	0

1/ Includes only hatched and predator-destroyed nests of the following species: mallard, scaup, gadwall, blue-winged teal, pintail, and shoveler. Excludes nests on mammal-free islands.
2/ The quantity of diffuse light (measured with nest site shaded) reaching the floor of the nest, expressed as a percentage of diffuse light immediately above the nest cover.
3/ Number of nests.

Fate of Nests on Different Sections of Study Area

Mammal-free Islands--The number of mammal-free islands during any 1 yr. varied from 4 to 7, depending on water levels in D-area Lake. From 1953 to 1957, 55 active and 15 terminated duck nests were found on these islands. Hatching success was very high compared to other sections of the study area, averaging 76 percent (Table 47). Two nests were lost to avian predators and none were destroyed by mammals. The chief causes of nest failure were flooding and desertion; some of the desertion may have been due also to rising water levels.

The main island-nesting ducks were scaups (25 nests) and mallards (19 nests). In view of the gadwall's reported preference for islands (Bent, 1923:80; Miller and Collins, 1954; Hammond and Mann, 1956), it was surprising to find just one nest of this species thus situated. Eight of the ten Canada goose nests that I discovered were located on islands.

Hammond and Mann (1956) speaking of island nesting by waterfowl stated: "When nest losses are low for a period of several years, high production may lead to good annual survival and, through 'homing' (Sowls, 1949), increase the number of potential nesting birds." Gross (1945) observed that increasing numbers of black ducks were nesting off the coast of Maine. There was some indication of a growing utilization of islands as nest sites during the last two years of the present study (Fig. 30). Numbers of island nests, active and terminated, over the 5-yr. period were: 1953--11, 1954--9, 1955--10, 1956--18, 1957--22.

TABLE 47.--SUMMARY OF FATE OF NESTS ON MAMMAL-FREE ISLANDS, 1953-57

Species	Deserted	Flooded	Avian Predation	Hatch	Total
Scaup	1	1	1	15	18
Mallard	1	3	1	10	15
Ruddy	1			5	6
Redhead				6	6
Canvasback	1	2		2	5
Blue-winged teal	1			1	2
Shoveler				1	1
Gadwall				1	1
Pintail				1	1
Totals	5	6	2	42	55
% Total nests	9	11	4	76 ± 11 1/	

1/ 95% confidence limits.

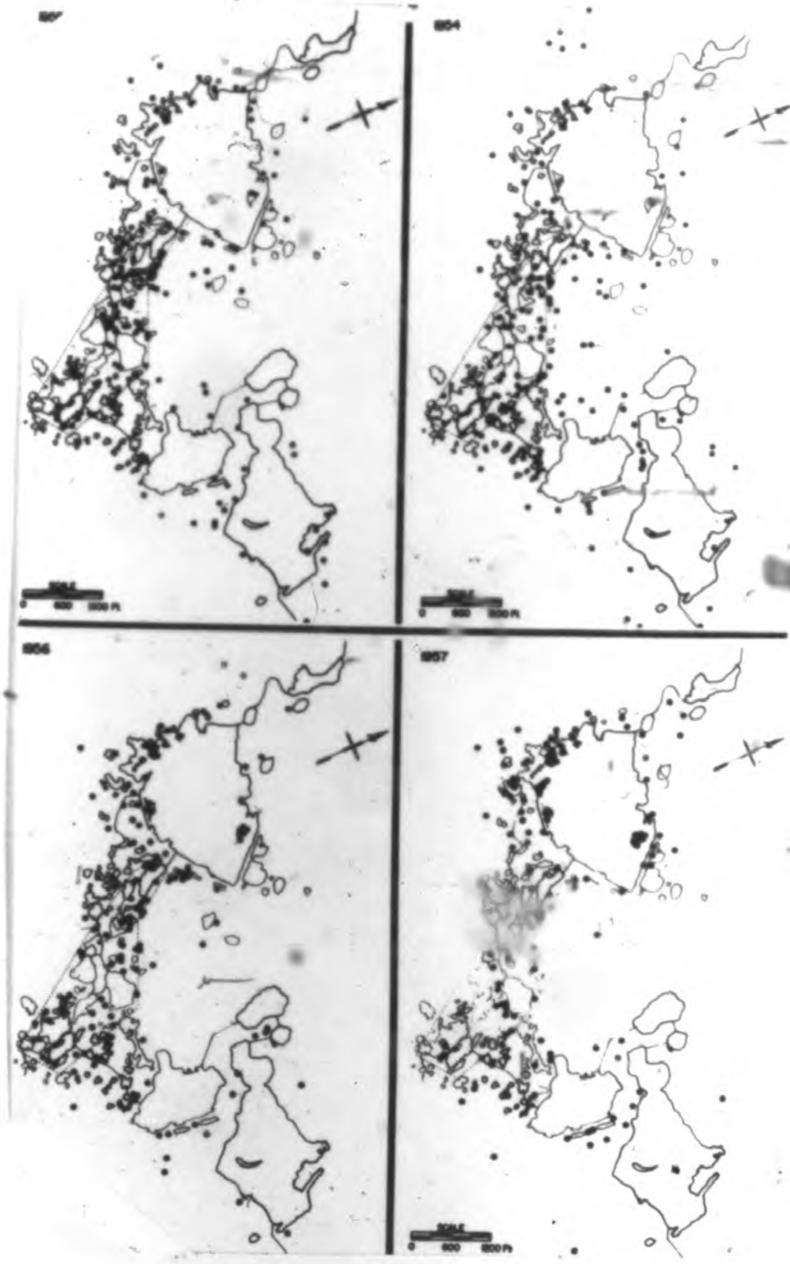

Fig. 30. Distribution of nests on study area, 1954-57.

Unfenced Mainland Areas--Hatching success on unfenced mainland areas was 35 percent (Table 48), less than half that on the mammal-free islands. Mammalian predators were primarily responsible for this decrease. The striped skunk accounted for most of the nest destruction, and very likely the coyote (included under unknown predation) was second in importance. Weasels killed 6 hens at 417 nest sites, and avian predators destroyed 8 nests (2 percent). No nests were lost to trampling by cattle.

Fenced A-area--In A-area, hatching success was significantly lower than on nearby unfenced areas—amounting to only 22 percent (Table 49). Increased predation, apparently due to skunks, was largely to blame for the further decline in percentage hatch.

The dense growth of vegetation that developed in the absence of grazing in A-area was very attractive to nesting waterfowl (Fig. 30). Active nest densities averaged 0.7 ac. per nest in terrestrial cover during the entire study, and attained 0.5 ac. per nest in 1953. Unfortunately, skunks were also attracted to this fenced area, for dens occupied much of the high ground, and tracks and scats were abundant. Bennett (1938b:100-102) too reported a marked increase in both skunk and badger populations after grazing was discontinued on a portion of his Iowa study area.

Solano Fenced Area--This fenced area, 1 mi. south of the main study area, consisted of 43 ac. of mainly mixed-prairie cover type. Nest densities were low compared to A-area, averaging approximately 4.5 ac. per nest yearly. Mean hatching success was 38 percent (Table 50),

TABLE 48.—SUMMARY OF FATE OF NESTS ON UNFENCED MAINLAND AREAS, 1953–57

Species	Deserted	Flooded	Predation				Hatch	Total
			Weasel	Skunk	Unknown Mammal	Avian		
Scaup	12		2	50	21	7	23	115
Blue-winged teal	10		2	20	12		40	84
Pintail	4			19	13		33	69
Mallard	4		1	20	8		16	49
Gadwall	8			14	9	1	6	38
Shoveler	4			9	3		16	32
Baldpate	1		1	6	1		3	12
Green-winged teal	3			3			2	8
White-winged scoter	1			1	1			3
Ruddy	1						2	3
Redhead							2	2
Canvasback	1						1	2
Totals	49	0	6	142	68	8	144	417
% Total nests	12	0	1	34 ± 5	16 ± 3	2	35 ± 5 1/	

1/ 95% confidence limits.

TABLE 49.--SUMMARY OF FATE OF NESTS IN A-AREA, 1953-57

Species	Deserted	Flooded	Predation				Hatch	Total
			Weasel	Skunk	Unknown Mammal	Avian		
Mallard	9	7	1	44	4	2	5	72
Blue-winged teal	9	1		25	3		19	57
Scaup	6		1	30	6	1	10	54
Gadwall	1			9	1	1	9	21
Redhead	3		1	7	1		3	15
Shoveler	2			9	1		3	15
Pintail	1			8	3	1	1	14
Green-winged teal				8	1		3	12
Canvasback	2	1		2	1		5	11
Baldpate	1			6	1		1	9
Ruddy	1		1		1		3	6
Totals	35	9	4	148	23	5	62	286
% Total nests	12	3	1	52 ± 6	8 ± 3	2	22 ± 5 1/	

1/ 95% confidence limits.

TABLE 50.--SUMMARY OF FATE OF NESTS IN FENCED AREA OF SOLANO PROJECT, 1954-57

Species	Deserted	Flooded	Predation				Hatch	Total
			Weasel	Skunk	Unknown Mammal	Avian		
Blue-winged teal	1			6	1	1	8	17
Pintail				3	3		4	10
Gadwall				3			4	7
Baldpate				3			1	4
Scaup				2			1	3
Mallard	1				1	1		3
Shoveler	—			2				2
Green-winged teal	1							1
Canvasback				1				1
Totals	3	0	0	20	5	2	18	48
% Total nests	6	0	0	42 ± 14	10 ± 8	4	38 ± 14 1/	

1/ 95% confidence limits.

resembling that in unfenced sections. As before, the skunk was the chief nest predator.

Renesting

Renesting is commonly presumed to play an important role in waterfowl production. The work of Sowls (1955) showed that when nests of marked hens were purposely destroyed, these birds often renested. Sowls found also that the "renesting interval" was a direct function of the stage of incubation at which the nest was destroyed, viz. 3 days plus 0.62 day for each day of incubation. Of the five species studied (mallard, pintail, blue-winged teal, shoveler and gadwall), he concluded (p.142) that "the pintail was the most persistent re-nester, and the blue-winged teal the least persistent."

Important questions on renesting remain unanswered, however, paramount among these is--what percentage of hens losing their first clutches under natural conditions attempt to renest?

Relationship of Nests Found to Pairs of Ducks Counted--When numbers of pairs and numbers of nests are compared, some marked differences are seen to occur between species (Table 51). The nests per pair ratio was lowest for baldpates, redheads and ruddies, and highest for mallards and canvasbacks.

The low nests per pair ratio among redheads and ruddies may be due to nonbreeders (Weller, 1956; Low, 1941) in the population. With baldpates, I suspect it was a matter of not locating the nests, for I consistently encountered few nests of this species even though broods were plentiful. Sowls (1950) mentioned briefly the trouble

TABLE 51.--RELATIONSHIP BETWEEN NUMBER OF NESTS FOUND AND NUMBER OF PAIRS 1/ COUNTED ON STUDY-AREA IMPOUNDMENTS, 1953-57

Species	Pairs	Nests Found				Total Nests Per Pair	Mean % Hatch 3/
		Active	Terminated	Unident. 2/ Terminated	Total		
Mallard	82	136	27	13	176	2.15	23
Canvasback	10	18	2	0	20	2.00	
Gadwall	47	60	10	5	75	1.60	27
Shoveler	42	48	8	4	60	1.43	42
Green-winged teal	15	20	1	0	21	1.40	
Blue-winged teal	153	143	40	19	202	1.32	42
Scaup	190	187	39	19	245	1.29	25
Ruddy	26	15	4	0	19	0.73	
Baldpate	39	21	5	2	28	0.72	
Redhead	58	23	3	0	26	0.45	
Totals and mean	662	671	139	62	872	1.32	

1/ Pintails are not included since it was felt that counts began during the first week of May were not always early enough to give an accurate estimate of the total number of pairs of this species present.

2/ Unidentified-terminated nests were arbitrarily divided among all species except canvasback, redhead, and ruddy, in the same proportion that identified-terminated nests were found.

3/ Active nests.

he had finding a particular baldpate nest during his study.

Over-all Renesting Rates--Information on breeding pairs and nests (Table 51) has been used to estimate over-all renesting rates for five species of ducks (Table 52). Calculations were based on several important assumptions, which in light of my field data and experience, I believe to be correct. These assumptions are listed and discussed in the Appendix.

The extent to which mallards renest, apparently surpasses that of gadwalls, blue-winged teal, scaups and shovellers (Table 52). According to these figures, unsuccessful mallard hens renested at least once, and 63 percent of the mallard hens having their first renest destroyed, attempted another renesting. Over-all renesting rates for the other species were: gadwall--82 percent, shoveler--75 percent, blue-winged teal--55 percent, and scaup--39 percent.

Bennett (1938b:58), comparing numbers of "renests" with numbers of destroyed nests, estimated that 40 percent of blue-winged teal hens renested. From similar data given by Glover (1956), I have calculated blue-winged teal renesting at 70 percent. During a study at Ogden Bay Refuge, Utah, in which incubated clutches were purposely destroyed, the over-all renesting rate for gadwalls was 96 percent (John Gates, unpublished data). Mendall (1958:122) thought that a minimum of 50 percent of initial losses resulted in renesting among ring-necked ducks. Hickey (1952:163) deduced from other population data that a considerable amount of renesting probably took place in the mallard. Although Sowls (1956) was not able to demonstrate a strong renesting tendency among mallards, he felt that this was

TABLE 52.—CALCULATED OVER-ALL RENESTING RATES IN FIVE SPECIES OF DUCKS, 1953-57

	Mall-ard	Gad-wall	Shov-eler	B.-w. Teal	Scaup
Total pairs	82	47	42	153	190
Total nests found	176	75	60	202	245
% Hatched	23	27	42	42	25
First nests	82	47	42	153	190
Hatched	19	13	18	64	48
Failed	63	34	24	89	142
First renests	63	28	18	49	55
Hatched	14	8	8	21	14
Failed	49	20	10	28	41
% Unsuccessful hens renesting	100	82	75	55	39
Second renests	31				
Hatched	7				
Failed	24				
% Unsuccessful hens renesting	63				
Successful hens					
Total number	40	21	26	85	62
Percent 1/	49	45	62	56	33

1/ Percent of those alive at start of nesting season.

nevertheless true, and cited brood data in support of his belief. Mallards, of course, are earlier nesters than any of the other four species considered in Table 52.

The percentage of hens that eventually succeeded in bringing off a brood was: shoveler--62 percent, blue-winged teal--56 percent, mallard--49 percent, gadwall--45 percent, and scaup--33 percent (Table 52). The arithmetic mean of these percentages is 49 percent.

Reduction in Clutch Size of Renests--Clutch sizes in renests are usually smaller than in first nests. Reductions in average size of renest clutches have been reported as: redhead--2.5 eggs (Low, 1945), several dabblers--2.0 eggs (Sowls, 1955:131), ring-necked duck--2.0 eggs (Mendall, 1958:84).

Arbitrary dates for "first nests" and "renests" were set (Table 53) after considering nest initiation data in Table 38. There will undoubtedly be some renests among the "first nests" and vice versa, but the resulting error is probably small. Differences between first and later clutches averaged: pintail--1.0 egg, mallard--1.5 eggs, shoveler--1.3 eggs, blue-winged teal--2.1 eggs, scaup--2.2 eggs. There is a suggestion here that later nesters exhibit the greatest reduction in clutch size.

Hatching Success

Comparison with Other Studies--In 1939, Kalmbach summarized hatching success in 22 waterfowl nesting studies (Kalmbach, 1939). Three of these studies, with an average percentage hatch of 70 percent, had been conducted on refuge areas using predator control. Three others,

TABLE 53.—COMPARISON OF CLUTCH SIZE IN "FIRST NESTS" AND "RENESTS" 1/

Species	"First Nests"		"Renests"		Difference
	Av. Clutch	Period	Av. Clutch	Period	
Pintail (57) 2/	7.2 ± 0.4 3/	Before May 16	6.2 ± 0.6	After May 31	1.0
Mallard (58)	9.6 ± 0.5	Before May 16	8.1 ± 0.4	After May 31	1.5
Shoveler (28)	10.7 ± 0.4	Before June 1	9.4 ± 0.6	After June 15	1.3
Blue-winged teal (57)	11.1 ± 0.3	Before June 1	9.0 ± 0.6	After June 15	2.1
Scaup (57)	10.6 ± 0.6	Before June 16	8.4 ± 0.7	After June 31	2.2
Average reduction in clutch size					1.6

1/ Periods arbitrarily set after consideration of data in Tables 31 and 38.
2/ Number of clutches.
3/ 95% confidence limits.

with an average percentage hatch approaching 70 percent, had been conducted at the Bear River Refuge, Utah, where nest predators were apparently scarce. Kalmbach obtained a mean hatching success of 60 percent, and stated that 70 percent was not an unreasonable objective on managed areas.

From that time on, Kalmbach's paper has been repeatedly quoted as showing that average waterfowl nesting success should be either 60 or 70 percent; and nesting studies yielding lower percentage hatches have often been regarded with either alarm or suspicion.

In 6 recent studies on typical sections of the Canadian prairies, involving over 3,500 nests, an average of 39 percent of dabbler nests and 54 percent of diver nests hatched (Table 54). The difference between the two groups appears to be the result of over-water nesting by many divers, which renders them largely immune to predatory mammals. The skunk and the crow were the most important nest predators.

Hatching success for dabblers was 34 percent in the present study, significantly different from only one of the five other investigations. For divers, hatching success was lower than reported elsewhere. This is because the scaup, which I never knew to nest over water, was the principal diver on the study area; while in other studies, the scaup constituted a much smaller fraction of the diver group.

As shown later under Productivity, average hatching success of the order given in Table 54, when coupled with our present knowledge of renesting, duckling survival, and juvenile and adult mortality

TABLE 54.—SUMMARY OF HATCHING SUCCESS REPORTED FROM SIX NESTING STUDIES CONDUCTED RECENTLY ON THE CANADIAN PRAIRIES

Region	Habitat	Period of Study	Dabblers		Divers		Chief Nest Predators
			No. Nests	% Hatch	No. Nests	% Hatch	
S.E. Alta.	Mixed prairie	1953-57 1/	556	34	250	31 7/	Skunk
S.E. Sask.	Parkland	1953-55 2/	966	36	131	61	Skunk-crow
S.Cent. Alta.	Parkland	1953, 1955 3/	255	38	83	48	Crow-skunk
S.Man.	Parkland	1949-50 4/	207	38	221	61	Not given
S.W. Man.	Parkland	1949-53 5/	368	42	391	69	Crow-mammal
S.W. Sask.	Mixed prairie	1955 6/	138	48			Skunk
Average % hatch		—		39		54	

1/ Present study.
2/ Stoudt et al. (1954, 1955, 1956).
3/ Smith (1954, 1956).
4/ Hawkins (1949, 1951).
5/ Kiel (1953, 1954).
6/ Reeves et al. (1956).
7/ Nests of divers here consisted largely of scaup which were never noted to nest over water.

rates, is more than adequate to maintain population levels.

Effect of Human Intrusion on Nest Predation

There has always been controversy over the effect of human intrusion on predation during nesting studies. Tracks and trails leading to nests, nest markers, disturbance of nest cover, and observation of nest-finding activity, etc. have been cited as evoking increased predation. Hammond and Forward (1956) thoroughly discussed this problem on the basis of extensive experience at the Lower Souris Refuge, and concluded that when reasonable care was exercised, these factors were usually of minor consequence.

They did feel, however, that defecation by flushing hens could lead to increased nest losses. Evidence for this was based largely upon a comparison of predation rates on "(1) nests from which hens had been flushed on a prior visit" and "(2) nests with the hens absent or not flushed on a prior visit." An experiment designed to test this hypothesis gave no significant differences between eggs smeared with fresh duck excrement and those left unscented.

I conducted a somewhat similar experiment during July 4-10, 1957. One hundred and fifty chicken eggs were set out singly, 10 ft. on either side of the fence surrounding A-area. Fifty were covered with duck excrement, placed by means of a cup tied to a 10-ft. pole, and had no tracks leading to them; 50 were handled only with gloves that had been boiled and buried to reduce fresh human scent, placed by means of the cup and pole, and had no tracks leading to them; and 50 were held freely with bare hands, and had tracks leading to them. An egg was set down opposite every third fence post (about every 45 ft.), alternately inside and outside the fenced area. Starting with the first egg, the treatments were randomized within consecutive three-egg groups.

When checked after 1-week's time, 59 of the 150 eggs had been eaten by predators. As far as could be determined from egg-shell remnants, all were taken by mammals. No significant difference in predation rate occurred between any of the treatments (Table 55). While I do not believe these results disprove the idea that excrement deposited by flushing hens causes increased predation, I do feel that duck-nest odors are sufficiently strong, without the addition of feces, to be easily detected by skunks and coyotes.

To test whether the number of visits to a nest, a function of the length of time under observation, affected predation, nesting data were organized as shown in Table 56. Seemingly, repeated visits had no effect. Predation on nests terminated before being found (Table 57) averaged 84 percent as compared to 54 percent for active nests. This tends to emphasize further that predation was heavy irregardless of human interference. Although as Kalmbach (1938) indicated, destroyed-terminated nests are more conspicuous than hatched-terminated nests. Thus percentage predation figures for active and terminated nests are not strictly comparable.

After considering these data, it is my opinion that human intrusion did not significantly increase nest losses during the present study.

TABLE 55.--SUMMARY OF RESULTS OF SCENTED-EGG EXPERIMENT

	Duck Excrement and no Tracks	Unscented and no Tracks	Fresh Human Scent and Tracks
No. eggs set out	50	50	50
No. destroyed	21	17	21
% Destroyed	42	34	42

TABLE 56.—RELATIONSHIP OF PREDATION ON NESTS TO DAYS UNDER OBSERVATION 1/

Stage Nests Discovered (Period After Laying Began)	Stages Nests Under Observation	Av. Period Nests Under Observation During Different Stages of Nesting	% Predation During Different Stages of Nesting	% Predation During Different Stages of Nesting (12-day Basis)	Total Av. Period Nests Under Observation
1-12 Days	1-12 Days	6 Days	22 (146) 2/	44 ± 8 3/	6 Days
	13-24 Days	12 Days	45 (114)	45 ± 9	18 Days
	25-36 Days	12 Days	52 (63)	52 ± 12	30 Days
13-24 Days	13-24 Days	6 Days	27 (226)	54 ± 6	6 Days
	25-36 Days	12 Days	42 (166)	42 ± 8	18 Days
25-36 Days	25-36 Days	6 Days	33 (54)	66 ± 13	6 Days

1/ Includes only hatched or predator-destroyed nests.
2/ Number of nests.
3/ 95% confidence limits.

TABLE 57.--SUMMARY OF FATE OF TERMINATED NESTS, 1953-57 1/

Species	Deserted	Flooded	Predation			Hatch	Total
			Weasel	Other Mammals	Avian		
Unidentified	3			68	3	4	78
Scaup	1	1	5	28	6	4	45
Blue-winged teal		1	4	27	1	11	44
Pintail			2	23	2	10	37
Mallard				26	2	4	32
Gadwall				10		1	11
Shoveler			4	4		2	10
Baldpate				5			5
Ruddy					2	2	4
Redhead				1	2		3
Canvasback					1	1	2
Green-winged teal				1			1
Totals	4	2	15	193	19	39	272
% Total nests	1	1	6	71 ± 5	7	14 ± 4 2/	

1/ Nests that had been deserted, flooded, destroyed by a predator, or hatched before being found.
2/ 95% confidence limits.

Summary

More than 500 ac. of cover were systematically searched for duck nests every 7-10 days from May through July, 1953-57. Dogs were used in nest hunting and accounted for a large proportion of the 806 active and 272 terminated nests that were found. Among the predominantly land nesters, scaups and mallards nested closest to water, and gadwalls and pintails nested farthest away. Nests of green-winged teal and blue-winged teal had the best concealment. Average clutch size was largest among blue-winged teal (10.4 eggs) and smallest among pintails (6.7 eggs). In successful nests, 7.3 percent of 1,446 eggs were nonviable. In the early-nesting pintail, 90 percent of the hatch was spread over about 65 days; in the late-nesting scaup, 90 percent of the hatch was confined to about 25 days.

Under current grazing pressures, 1.2 ac. per head per mo., July-November, nesting cover for ducks on the study area was not seriously reduced. The unpalatability of Calamovilfa longifolia and Juncus balticus to livestock has played a key role in maintaining this cover. Two important factors in the selection of terrestrial nesting cover were concealment value and proximity to water. The overall nest density, including terminated nests, was 2.6 ac. per nest. It was determined that nesting began progressively earlier each year from 1953 to 1957. No consistent relationship was found between relative earliness of nest initiation and temperature and rainfall data. A heat-sum taken each year during April 10-28 gave a highly significant correlation coefficient, but this result is viewed with some reserve. During the last week of April, in both 1954 and 1956,

daily mean temperatures averaged in the mid-20's, nightly lows dropped to 12-14 F., and approximately 5 in. of snow fell. This period corresponded to the laying and early incubation stages of most successfully hatched pintail nests. In 1953, a May 10 blizzard with subfreezing temperatures, and a June 1-3 rainfall of almost 5 in. apparently failed to cause increased abandonment of nests.

The striped skunk was the chief nest predator, accounting for at least 70 percent of the predation on active nests. The rate of nest destruction by predators increased significantly during the season. There was no evidence that the vulnerability of nests to predators varied from the onset of laying to the time of hatching. Predation on nests in cattail and *Juncus* cover was much greater than in other terrestrial cover types. This was attributable to higher nest losses within the first 25 ft. from water. Such losses appeared to be unrelated to nest density or to concealment, and it is suggested that the explanation may rest with the feeding behavior and/or movements of the skunk. Hatching success ranged from 76 percent on mammal-free islands, to 35 percent on unfenced mainland areas and 22 percent in fenced A-area. The low hatching success in the latter was caused by a high skunk population, probably attracted there by the dense cover which developed after fencing. Over-all renesting rates calculated from data on numbers of pairs, numbers of nests and hatching success were: mallard--163 percent, gadwall--82 percent, shoveler--75 percent, blue-winged teal--55 percent, scaup--39 percent. Renests averaged 1.6 eggs per clutch fewer than first nests. Waterfowl hatching success on the Canadian prairies, as revealed by 6 recent nesting studies including the present one, averaged 39 percent for dabblers and 54 percent for divers. The effect of human intrusion on nest destruction by predators is discussed. It is concluded that during the present study, such nest losses were not significantly increased through the activities of the investigators.

PRODUCTIVITY

The aging and enumerating of broods provided information on (1) duckling mortality, (2) movements, (3) impoundment usage, and (4) response to changes in shoreline type. Data on nest initiation and hatching periods, derived from back dating aged broods, have been discussed under Nesting.

Methods

Brood Counts--The first broods of pintails usually appeared on the study area during the last week of May; brood counts were conducted from that time until the last week of August. These counts were augmented with brood data that I collected from other Ducks Unlimited projects within a 10-mi. radius.

Broods were aged by plumage characters as outlined in Blankenship *et al.* (1953). However, I segregated the "downy" plumage class (class I) into two, rather than into three subclasses. At distances of several hundred yards, or in poor light, it was often difficult to distinguish between the three subclasses described by Blankenship. Driving broods from shoreline cover was tried, but proved more time consuming and probably less effective than sitting or laying quietly beside water areas at feeding periods. Warm calm afternoons and evenings seemed best for this purpose.

A concerted effort was made to observe as many broods on the study area as possible during each of their six age groups, viz. early and late classes I, II, and III. Special attention was given to

A-area Potholes in order to secure the same proportion of broods as counted on impoundments with little emergent vegetation. A record was kept on the size, species, age and location of each brood seen. The list of broods compiled daily was checked against past observations on the same waters, and those thought to be repeats within subclasses were eliminated. Some duplication was of course unavoidable, especially when broods were actively moving from one lake or pothole to another.

Duckling Mortality

Stage of Greatest Mortality--Published waterfowl-production studies have unanimously shown that duckling mortality is highest within a week after hatching (Low, 1945; Earl, 1950; Miller and Collins, 1954; and others). Mendall (1958:140) believed that most of this loss occurred within the first 48 hr. Clutch and brood-size data collected in the present study (Fig. 31) indicated an average decrease of about two ducklings per brood (24 percent) from hatching to the flying stage. Two-thirds of this reduction took place within the first week. Of 25 ducklings found dead in 1957, 12 (48 percent) were less than 1 week old.

There are likely two reasons why the last three points in Fig. 31 gave average brood sizes above the expected, viz. aggregation of older broods, and the fact that many smaller broods from renests were still fairly young at the time counts were discontinued.

Comparisons of mean clutch and early class-I brood sizes for eight species of ducks (Table 58), showed that losses of eggs and

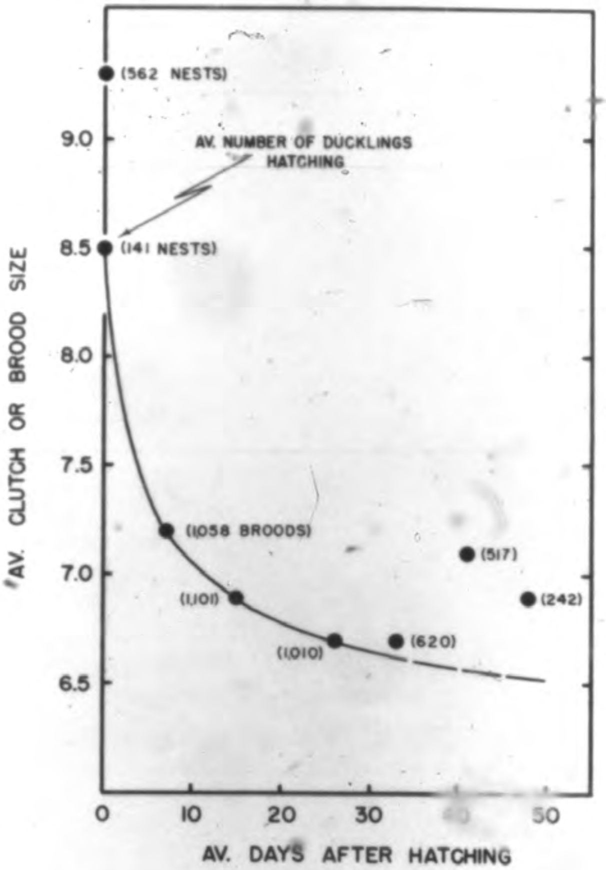

Fig. 31. Average losses, excluding nest predation, from completed clutch (mean, 9.3 eggs) to approximately flight age. Calculated from data for pintails, mallards, blue-winged teal, shovelers, baldpates, gadwalls, redheads and scaups.

TABLE 58.--DIFFERENCE BETWEEN AVERAGE CLUTCH SIZE AND AVERAGE EARLY CLASS-I 1/ BROOD SIZE

Species	Av. Size Clutches	Av. Size Early Class-I Broods	Dif.	% Dif.
Redhead	10.1 (21)2/	6.9 (56)3/	3.2	32
Shoveler	10.1 (45)	7.1 (144)	3.0	30
Blue-winged teal	10.4 (114)	7.5 (282)	2.9	28
Baldpate	8.9 (20)	7.2 (75)	1.7	19
Gadwall	9.4 (55)	7.7 (90)	1.7	18
Mallard	8.8 (97)	7.2 (57)	1.6	18
Scaup	10.0 (131)	8.3 (145)	1.7	17
Pintail	6.7 (79)	5.8 (209)	0.9	13

1/ Age range of early class-I broods was from 1 to 9-13 days, the latter figure depending on the species.
2/ Number of nests.
3/ Number of early class-I broods.

young from successfully hatched nests were twice as great among redheads, shovelers and blue-winged teal as among pintails. The small sample of hatched clutches precluded a satisfactory analysis of posthatching mortality for each species, but there are strong indications that increased loss of ducklings, and not decreased egg viability, largely accounted for the above differences. Average mortality from completed clutch to observed early class I did not change significantly in early, medium and late hatchings. For no species was mean clutch size or mean early class-I brood size significantly different between years.

Decimating Factors—Three instances of predation on ducklings were witnessed—a marsh hawk taking an early class-I gadwall, a California gull taking an early class-I blue-winged teal, and a Swainson's hawk taking an early class-III pintail. Both hawk kills were made on land, while the gull snatched its victim from the water. Young ducks generally paid scant attention to marsh hawks, but young coots and redwinged blackbirds quickly sought cover whenever one appeared.

Dogs used in the nesting study frequently located broods traveling between water areas; coyotes and weasels were undoubtedly as efficient in this regard, and must have inflicted considerable losses at such times. The vulnerability of broods to mammalian predation was probably increased when broad expanses of mudflat separated the water's edge from riparian vegetation. Under these circumstances, ducklings caught loafing or sleeping in shoreline cover would have found it difficult to elude predators skirting the mudflats. Tracks of coyotes and skunks were always plentiful there.

Munro (1941) declared that one of the chief causes of death among scaup ducklings in British Columbia was drowning or suffocation after becoming entangled in weeds or mats of filamentous algae. I doubt that this factor was too important on the study area; nevertheless, a heavy scum of Cladophora sp. supported by Myriophyllum exalbescens was commonly formed when water levels were low. Broods quickly abandoned such places. The bottoms of lakes and potholes also were sometimes covered with this algae. In attempting to escape capture on banding drives etc., young ducklings often dove and became thoroughly entrapped in submergent algal masses. Theoretically, harassment by predators could have produced the same effect.

Most small ducklings that were picked up dead bore no outward signs of injury. Unfortunately, many were in advanced states of decomposition and gross post-mortem findings were hard to appraise. Two pintails, one dead and the other in a morbid condition, were found to be severely infected with intestinal worms including the acanthocephalan (Corynosoma constrictum). Tapeworm infections--of uncertain significance--were extremely prevalent.

No serious hail storms occurred on the study area, however, in 1953 extensive adult and brood mortality from hail was recorded in some parts of the province (Smith and Webster, 1955).

Mendall (1958:144) listed the chief decimating factors on young ringnecks in Maine as exposure, accidents and predators. Although lacking proof, I suspect that duckling mortality on my study area was primarily the result of (1) a combination of exposure, congenital weakness and heavy parasitism, and (2) predation.

Brood Movements

Over-all movements of broods in relation to impoundment size were investigated by determining the average age of broods on various waters (Table 59). I thought that a major shift in brood distribution would raise average age values on those impoundments gaining broods. If movements were independent of impoundment size, average age values would be similar on all water areas.

Data in Table 59 indicate a limited egress of broods from potholes 1 ac. or less into larger potholes and lakes. Once beyond 1 ac., size *per se* has seemingly little bearing on brood movements. A decided shifting of broods from small to larger waters has been reported previously by Low (1945), Evans *et al.* (1952) and Berg (1956). On the study area, the relative permanency of many smaller potholes may have tended to discourage brood mobility.

Usage of Study-Area Subdivisions by Broods, 1953-57

The luxuriant cattail growth in A-area was not frequented by unusually large numbers of broods. Brood usage here was comparable to that of Cz- and Cy-area Lakes, and somewhat higher than that of D-area Lake and B-area Potholes (Fig. 32).

Brood-observation data for 1953-57 contain a number of suggestions of species preference. Gadwall and baldpate broods, for instance, were not seen on the small potholes of B-area, but were very abundant on Cz-area Lake. Broods of diving ducks also avoided B-area's potholes. The shallowness of these waters was probably important in this connection since potholes of equal size, but twice

TABLE 59.--AVERAGE AGE OF BROODS USING STUDY-AREA IMPOUNDMENTS OF DIFFERENT SIZE

Impoundments			
No.	Av. Size (ac.)	Size Range (ac.)	Av. of Brood Ages (days)
45	0.5	≦1.0	18 (473)1/
6	2.5	>1.0-4.2	23 (379)
1	20.8		23 (501)
1	48.4		23 (844)
1	71.4		24 (930)

1/ Number of aged broods.

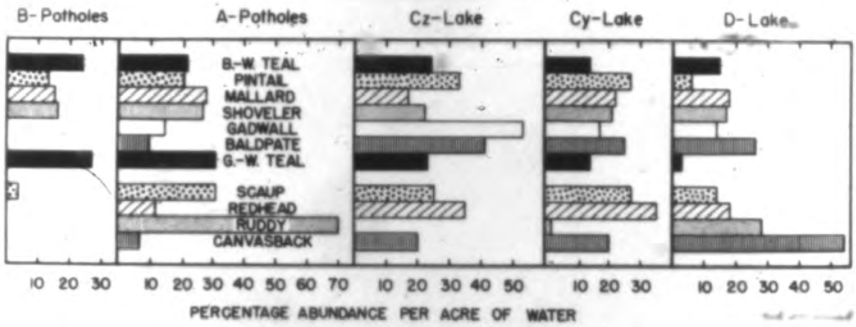

Fig. 32. **Average usage of different impoundments of the study area by broods, 1953-57. Percentage abundance is the average number of pairs per acre of water, expressed as a percentage of: Σaverage pairs per acre of water on each of the study area's five subdivisions.**

as deep (5-6 ft.), regularly held broods of young divers. Ruddy broods displayed a strong preference for areas with emergent vegetation (A-area Potholes and D-area Lake), while canvasbacks were drawn mainly to the larger impoundments. Shovelers and blue-winged teal appeared to be least affected by differences in size, depth, shoreline type, etc.

Except for pintails, which scarcely used D-area Lake, there was a good correlation in relative use of Cy- and D-area Lakes by broods of the dabbling species. The percentage abundance of diver broods on Cy- and Cz-area Lakes was almost identical.

Response of Broods to Changes in Shoreline Type

Effect of Rush-Grass vs. Mud Shorelines--Average percentage abundance of broods on lakes decreased 23 percent in years when rush-grass shorelines were replaced by mud (Table 60). Other investigators have likewise noted fewer broods where mud shorelines existed (Evans, 1949; Bue et al., 1952; Smith, 1953; Berg, 1956). Considering the marked difference in rush-grass and mud-type shorelines, and the supposed attractiveness to broods of cover in juxtaposition with water, I am surprised that brood reaction was not more pronounced. In light of present knowledge of brood mobility (Evans et al., 1952; Berg, 1956), distances between these impoundments would not likely have discouraged movements.

The greatest responses by broods to lake shoreline changes were observed on Cz-area Lake in 1954, and Cy-area Lake in 1955. In each case water levels had been very low during the two preceding

TABLE 60.—USAGE OF THREE STUDY-AREA LAKES BY BROODS IN RELATION TO SHORELINE TYPE

Shoreline Type	Av. Percentage Abundance 1/ of Broods			
	D-area Lake	Cy-area Lake	Cz-area Lake	Av.
Mud 2/	11 (1)3/	18 (3)	22 (2)	17
Rush-grass 4/	17 (4)	22 (2)	28 (3)	22

1/ The average number of broods per acre of water, expressed as a percentage of Σ average number of broods per acre of water on each of the study area's five subdivisions.

2/ At least 18 in. of mud beyond shoreline vegetation; usually much wider expanses of mud-flat.

3/ Number of summers.

4/ Mainly *Juncus balticus*, *Hordeum jubatum*, and *Carex* spp.

years and had resulted in extreme mudflat conditions. The exposed mudflats were a fertile seedbed for moist-soil plant species, and these pioneered a band of former lake bottom. Hence, when the levels of Cz- and Cy-area Lakes were subsequently raised about 2 ft. during mid-August of 1953 and 1954 respectively, a 20- to 100-ft. margin of vegetation was flooded. The percentage abundance of broods on Cz-area Lake climbed from 7 percent in 1953 to 22 percent in 1954, and on Cy-area Lake percentage abundance climbed from 19 percent in 1954 to 39 percent in 1955.

Effect of Partial Destruction of Shoreline Cattail--The herbicide treatment of cattail in A-area and its effect on stands of this emergent have been outlined earlier. There was a notable response by broods of all species to the partial removal of shoreline cattail. During the three years prior to spraying, brood numbers on potholes that were later sprayed varied from 1.8 to 0.8 times those on unsprayed potholes (Table 61). The effect of the herbicide on cattail was most apparent in 1956, and the number of broods using sprayed potholes was 12.9 times the number using unsprayed potholes. This ratio dropped to 3:1 in 1957 as cattail stands regenerated on treated sites and became uniform once again.

Reasons advanced previously for increased utilization of sprayed potholes by adult ducks were likely also associated with increased utilization by broods.

Production on Study Area

Average Yearly Production--The estimated number of breeding pairs on

TABLE 61.--EFFECT OF PARTIAL DESTRUCTION OF CATTAIL BY HERBICIDE SPRAY ON BROOD USAGE OF A-AREA POTHOLES

Treatment	Broods per Acre on A-area Potholes				
	1953	1954	1955	1956	1957
Unsprayed	2.4	5.3	3.2	1.0	2.2
Sprayed mid-Aug. 1955 1/	3.0	9.5	2.7	12.9	6.6
Ratio	1.3	1.8	0.8	12.9	3.0

1/ Cattail greatly reduced on sprayed potholes during summer of 1956; much less so during 1957.

censused impoundments during 1953-57 averaged 155 per year (see Table 25). Uncensused waters on the study area mainly resembled B-area Potholes, but had approximately two and one-half times as much shoreline. Two small impoundments at the west end of Cy-area Lake most nearly resembled it; their total shoreline was roughly one-quarter that of the lake. Since an average of 18 pairs per year frequented B-area Potholes, and 35 pairs frequented Cy-area Lake, I believe that uncensused impoundments likely contributed about 54 (45 + 9) additional pairs. This gives a total of 209 breeding pairs annually for the entire study area.

Renesting information for mallards, gadwalls, shovelers, blue-winged teal and scaups (see Table 52) indicated that an average of 49 percent of the hens were eventually successful in bringing off a brood. The mean number of young per brood reaching the flying stage was around 6.5 (see Fig. 31). By utilizing these data, yearly production was computed to average 666 ducks (209 x 0.49 x 6.5), or 3.7 birds per acre of water.

<u>Average Cost of Production</u>--Maintenance costs (administrative overhead, repairs to dams and structures, etc.) for the Will J. Reid project and the Solano extension in the 12-year period, 1947-58 inclusive, totalled $2,538 (Angus Gavin, <u>in litt</u>.). Inasmuch as the study area constituted nearly one-quarter of this scheme, its share was arbitrarily considered as $635, or $53 annually over the 12 years.

Assuming that productivity during the study was representative, the mean cost of each duck raised to flight stage has been $0.08 ($53/666). This does not take into account the initial construction costs of

$38,679 for the entire project. Naturally, the greater the span of time over which these are prorated, the less important they become. If the initial cost of the project is written off over a 30-year period, and if production remains about the same, the total cost per duck raised on the study area will be $0.56 ($0.48 + $0.08) for the first 30 years, and $0.08 thereafter. Such expenditures are well below the $2.04 (exclusive of releasing costs) required to raise artificially 30-day old mallard ducklings in Wisconsin (Hunt et al., 1958).

Average Cost Per Duck Bagged--To obtain the cost per duck bagged, it is necessary to know the percentage of birds taken by hunters. One method of accomplishing this is to use band-recovery rates, and to multiply these by a correction factor for unreported bands.

The recovery rate of waterfowl banded by Ducks Unlimited between 1939 and 1954 was 10.9 percent (Cartwright, 1956). Suggested correction factors for unreported bands are 2.1 (Ryder, 1955), 2.3 (Hickey, 1955), 2.8 (Hunt et al., 1958), and 2.9 (Bellrose and Chase, 1950). I elected to use 2.5, the mean of the above values. The percentage of ducks bagged is thus about 27 percent (10.9 x 2.5). The cost per bird bagged would be $2.07 ($0.56 x 100/27) during the first 30 years, and $0.30 ($0.08 x 100/27) thereafter. Charges per duck bagged on shooting preserves currently range from $3.00 to $7.00, the usual price being $5.00 (Dickey, 1958).

Prairie Breeding Grounds

Generalized Picture of Waterfowl Population Dynamics--Our present knowledge of juvenile and adult mortality rates, summarized in Table 62, is incomplete for most species of ducks. Available data imply an annual adult mortality rate approaching 50 percent, and a juvenile mortality rate near 70 percent. Ten recent studies on the Canadian prairies and in the Dakotas indicated that an average of about 49 percent of nesting females ultimately produced broods (Table 63). With the exception of the present study, published figures on the percentage of successful hens have been estimated by comparing breeding pair numbers in spring with brood numbers later on. The mean class-III or near-flight brood size was 6.3 (Table 63).

The plausibility of current information on waterfowl mortality and reproductive rates is best explored in a stochastic model. To avoid complications arising from sex-ratio changes, I have dealt only with the female segment of the population (Table 64). The seemingly conservative assumptions were that:

1. The average adult mortality rate is 50 percent annually (September 1 to September 1).

2. The average juvenile mortality rate is 70 percent annually (September 1 to September 1).

3. Mortality within each age class is uniform throughout the year. This is undoubtedly not the case, but errors arising from the assumption are probably not serious.

4. The sex ratio of juveniles as of September 1 is 52 percent males to 48 percent females (Sowls, 1955:164—sex ratio at hatching).

5. Forty-five percent of the females present on May 1 successfully hatch off a brood.

TABLE 62.—AVERAGE ANNUAL MORTALITY RATES CALCULATED FROM BAND-RETURN DATA

Species	Annual Mortality Rates			Source
	Adults	Juveniles	All Age Classes	
Mallard	48	68 1/		Hickey (1952).
Mallard	40♂♂	55♂♂	46	Bellrose and Chase (1950).
Mallard	38 2/			Recalculated from Ryder (1955).
Mallard			58	Calculated from Van Den Akker and Wilson (1949).
Mallard	58	75		Hunt et al. (1958).
Pintail	50			Sowls (1955:30), after Munro (1944).
Pintail			44	Calculated from Van Den Akker and Wilson (1949).
Redhead	55	70 1/		Hickey (1952).
Redhead			77	Calculated from Van Den Akker and Wilson (1949).
Gadwall 3/			52	Calculated from Van Den Akker and Wilson (1949).
Baldpate 3/			54	Calculated from Van Den Akker and Wilson (1949).
Shoveler 3/			58	Calculated from Van Den Akker and Wilson (1949).
Green-winged teal			48	Calculated from Van Den Akker and Wilson (1949).
Blue-winged teal			57	Bellrose and Chase (1950).

1/ May be biased (too high).
2/ Correction made for incomplete returns.
3/ Based on less than 90 band returns.

TABLE 63.--SUMMARY OF RECENT WATERFOWL PRODUCTION DATA FROM THE CANADIAN PRAIRIES AND THE DAKOTAS

Region	Approx. Percentage Hens Raising Broods	Average Class III of Near-Flight Brood Size	Period of Study	Source
South Dakota	65	5.9	1950-51	Bue et al. (1952).
S.W. Manitoba	56	6.5	1949	Evans et al. (1952).
S. Saskatchewan	53	5.7	1949	Lynch (1949).
S.W. Manitoba	52		1952-55	Dzubin (1956).
North Dakota	51		1955	Bue and Fashingbauer (1956).
S. Saskatchewan	51		1952-55	Sterling (1956).
S.E. Alberta	49	[illegible].5	1953-57	Present study.
S.W. Saskatchewan	47	6.3	1950-56	Leitch (1956).
S.E. Saskatchewan	38		1952-55	Stoudt and Yeager (1956).
S.W. Saskatchewan	31	6.5	1955	Reeves et al. (1956).
North Dakota		6.8	1954	Fashingbauer and Sjordal (1955).
North-South Dakota		6.8	1949-53	Stoudt (1954).
S.W. Manitoba		6.8	1949-53	Kiel (1954).
S. Saskatchewan		5.3	1953-54	Gollop and Lynch (1955).
Mean	49	6.3		

TABLE 64.—AGE STRUCTURE OF FEMALE COMPONENT OF HYPOTHETICAL DUCK POPULATION OVER A 2-YEAR PERIOD 1/.

Year	Date	Number of Females								Total
		Cohort 1		Cohort 2		Cohort 3		Cohort 4		
		No.	Age	No.	Age	No.	Age	No.	Age	
A	May 1	133	(>1 yr., adults)	155	(<1 yr., juveniles)					288
	Sept. 1	100	(≧2 yr., adults)	100	(1 yr., adults)	359	(<1 yr., juveniles)			559
B	May 1	67	(>2 yr., adults)	67	(>1 yr., adults)	192	(<1 yr., juveniles)			326
	Sept. 1	50	(≧3 yr., adults)	50	(2 yr., adults)	108	(1 yr., adults)	406	(<1 yr., juveniles)	614

1/ Based on the following assumptions:
(1) Average adult mortality rate—50 percent annually (September 1 to September 1).
(2) Average juvenile mortality rate—70 percent annually (September 1 to September 1).
(3) Mortality uniform throughout the year.
(4) Sex ratio of juveniles as of September 1—52 percent males:48 percent females.
(5) Forty-five percent of females present on May 1 successfully raise a brood.
(6) Six young per brood survive to flying stage as of September 1.

6. Six young per brood survive to the flying stage as of September 1.

Under such conditions the hypothetical group of females in Table 64 increased almost 11 percent per year. Other factors remaining constant, the percent of successful hens could drop to 42 percent, from the assumed 45 percent, without initiating a population decline. The number of juveniles (both males and females) per adult female in Table 64 is 4.3:1 on September 1 of year A, and 4.7:1 on September 1 of year B. These ratios are very close to the 4.4:1 reported by Sowls (1955:164) for ducks, exclusive of redheads and canvasbacks, bagged on the Delta Marsh.

I believe one may safely conclude that, on the whole, waterfowl productivity rates in recent studies have equalled or exceeded mortality rates computed from band returns. It does not necessarily follow, of course, that total production on the prairies has equalled or exceeded total mortality, since only a small portion of this vast region was represented in the above studies. These data suggest, however, that when water is available throughout the season, waterfowl production is generally sufficient to compensate for annual losses. The management implication here is clear, viz. establishment of permanent water areas is an important step towards insuring adequate waterfowl production.

Summary

Duckling mortality between hatching and flying averaged 24 percent, two-thirds occurring within the first week. Losses of eggs and early class-I ducklings from successfully hatched nests were twice as great among redheads, shovelers and blue-winged teal as among pintails. Duckling mortality on the study area was believed primarily due to (1) a combination of exposure, congenital weakness and heavy parasitism, and (2) predation. Broods tended to move from potholes of 1 ac. or less to larger potholes and to lakes. Over-all usage of A-area's cattail-fringed potholes was comparable to usage of Cz- and Cy-area Lakes, and somewhat higher than B-area Potholes and D-area Lake. The average percentage abundance of broods on lakes was 23 percent lower with mud shorelines than with rush-grass shorelines. Partial destruction of cattail in three A-area potholes caused a sharp rise in utilization by broods of all species.

The average number of ducks produced on the study area each year was calculated at about 666. If initial construction costs are written off over a 30-year period, the total cost (including maintenance) per duck raised would be $0.56 during this time, and the total cost per duck bagged $2.07. Thereafter, the cost per duck raised and the cost per duck bagged would be $0.08 and $0.30 respectively. Waterfowl productivity on prairie breeding grounds, as indicated by recent studies, was found to be more than adequate to counteract losses estimated from available mortality-rate data.

MANAGEMENT

The usual goal of wildlife management is to increase productivity. Waterfowl production may be affected by changes in (1) breeding-population density, (2) nesting success, and (3) duckling survival. In the following discussion, management of the study area and of similar projects is considered in terms of these three factors.

Breeding Population Density

In years when abundant surface water exists throughout the season on the mixed prairie, the over-all contribution of artificial impoundments may be relatively small. When the prairies are dry in early spring, duck numbers on impounded waters tend to be higher, but most waterfowl apparently shift into the parklands to breed (Lynch, 1949; Smith, 1949). Critical years for ducks are generally characterized by a surfeit of natural ponds in April and May, followed by drought and the rapid disappearance of these ponds during June and July. It is in such years that the value of permanent impoundments is greatest, for they save a portion of the duck crop which is normally lost. If, in addition, permanent impoundments can be made more attractive to breeding birds than are the natural drought-susceptible potholes, losses from drought will be reduced even further.

Many water areas in southern Alberta dried up during the latter half of May 1957; and although the study area experienced a temporary influx of adult ducks at that time, they evidently did not renest. Presuming this behavior is typical of drought-evicted birds, it is then essential that waterfowl be drawn to permanent lakes and potholes before nesting is underway. Management techniques seeking to accomplish this must be ecologically sound, inexpensive, and easily implemented.

The most effective means of attracting breeding waterfowl will vary with local conditions. On the study area, marked changes in the physical appearance of shorelines (mud to rush-grass and vice versa) had little effect on spring usage of lakes by adult ducks. There was no shortage of nesting cover here in spite of grazing, since major terrestrial plant communities were dominated by unpalatable species. Thus, shoreline manipulations and/or improved cover would not likely increase breeding populations. Food, however, was one factor to which ducks responded quickly, and it may well prove capable of attracting and holding larger spring populations.

In Montana, Girard (1941) successfully used grain to attract mallards during spring, and thereby increased the number of breeding birds. Mendall (1949b) reported comparable results with ringnecks and black ducks in Maine after food plantings were made. Obviously, costs and distribution problems make the extensive utilization of grain impractical; and, as discussed under Food Habits, artificial plantings are largely unnecessary in the region of the study area.

The stimulation of seed production among submergent aquatics by slowly declining water levels, and the subsequent reaction of waterfowl to the gradual reflooding of these exposed beds during August, has been described previously. I believe that this same principle could be used to attract breeding birds in spring. What I suggest is that water levels be permitted to decline on certain key impoundments after the end of June, and that reflooding be delayed until the following April. The chief problem would be to obtain sufficient water at that time. On the Will J. Reid project, for example, surplus irrigation water is not usually available until the end of May or early June, but there is often considerable spring runoff through Crab Lake spillway that might be utilized. Many extant Ducks Unlimited projects are not suited to purposeful water-level manipulations because of their general layout or the absence of necessary control structures. When water flows through a continuous series of lakes and potholes, it is difficult, if not impossible, to lower water levels on some without similarly affecting others. I do not propose, nor do I feel qualified, to deal with the engineering aspects of project design, however, by-pass ditches and additional controls are probably feasible in numerous instances.

Widespread implementation of this scheme would be easiest where advantage was taken of normal evaporation to lower water levels in mid-summer, and where the impoundments concerned were initially engineered to receive available runoff in spring. If submergent vegetation was not too plentiful, smartweeds might be seeded on dried lake bottoms during one year, and flooded the next. Leitch (1951) stated that the attractiveness of smartweeds planted on some Alberta projects seemed to be keeping pintails out of nearby pea fields in late August and early September.

Nesting Success

Over 50 percent of the nests on the study area were destroyed by predators, and at least 70 percent of this predation was caused by striped skunks. Because of the high proportion of nest losses attributable to these animals and the comparative simplicity of the predator community, a reduction in skunk predation might reasonably be expected to increase nesting success.

Poisoning and trapping may be partially effective in restricted areas with dense skunk populations, but the cost of any large-scale control program based on such measures would be prohibitive. More practical approaches are (1) to avoid developing habitat that is attractive to both skunks and nesting ducks, and (2) to create waterfowl nesting sites that are inaccessible to skunks.

Skunks prefer heavy ungrazed cover. The fenced portion of the study area (A-area) provided an excellent illustration of how increased cover may benefit skunks and sharply reduce hatching success. The combination of high skunk densities and high nest densities was largely responsible for a hatch of only 22 percent in the fenced area, as against 41 percent in immediately adjacent but unfenced B-area. Similar observations were made by Bennett (1938b:100-102) in Iowa.

In my opinion, one of the most promising ways of circumventing skunk predation is through the creation of <u>small</u> nesting islands. Hammond and Mann (1956) have discussed waterfowl usage and other aspects of nesting islands on the Lower Souris Refuge in North Dakota.

Hatching success on islands occurring fortuitously on the study area averaged 76 percent, compared with 30 percent on the mainland. If an average of 80 percent of unsuccessful hens renested (see Table 52), 91 percent of the island-nesting birds could have produced broods in contrast to 47 percent of the mainland nesters. The islands most heavily used for nesting were 1-2 ft. above the high-water mark, and at least 50 ft. in diameter. Islands like these could easily be built with a bulldozer and scraper during the construction of new projects, or after water levels had been lowered on present ones. A channel 1.5-2 ft. deep and approximately 30 ft. wide was adequate to deter skunks on the study area, hence islands can probably be made in shallow waters and costs of construction minimized.

The smallness of these islands is an important feature because: (1) stray skunks and other mammalian predators do not become permanent residents of the islands, (2) California and ring-billed gulls (potential nest predators) are discouraged from nesting, and (3) cattle are less inclined to wade out and graze them.

To help prevent erosion on newly created islands, combine-screenings or weed seeds from grain cleaning plants might be scattered over the bare ground. The ensuing growth would also provide nesting cover until permanent vegetation became established. In the vicinity of the study area, the paucity of cover on islands in saline lakes greatly reduces their usage for nesting by ducks. In nonsaline waters, a cattail fringe quickly encircles islands and efficiently combats shoreline erosion.

The development of such cattail stands is especially significant, since they provide over-water nesting sites for diving ducks, without the attendant disadvantages and problems of shoreline fencing.

The futility of trying to establish stands of softstem bulrush for this purpose when muskrats are abundant was mentioned earlier. In this region, islands would likely be utilized mainly by mallards, scaups, redheads, canvasbacks and Canada geese. Gadwalls are important island nesters in other localities (Hammond and Mann, 1956).

Crows and magpies were not plentiful on the study area, and consequently were minor duck-nest predators. I suspect, however, that unless the operation of fenced areas is discontinued and further development of willow and aspen stands thereby prevented, sizable resident populations of crows and magpies may soon be present. The first crow and magpie nests have already appeared.

Duckling Survival

Duckling mortality is greatest during the first few days after hatching. The chief decimating agents are not known for certain, but I suspect the combination of exposure and congenital weakness is predominant at that stage. There is, to my knowledge, nothing practical one can do to mitigate these losses. Increased vulnerability to mammalian predators, arising from extensive mud shorelines, should of course be avoided by maintenance of favorable water levels whenever possible.

Other Management Considerations

Introduction of Fish—Ducks Unlimited's projects by and large do not support resident fish populations. While some pike are introduced from time to time via irrigation ditches, the shallowness of these lakes and potholes makes winter kills (resulting from oxygen depletion) almost certain. Losses of ducklings to predaceous fish are thus probably insignificant. A much more serious threat to waterfowl in areas where sport fish occur, is the general disturbance caused by fishermen. Fishing is a popular recreation on the prairies, and available waters are heavily used. Breeding birds and their young apparently find this type of disruption intolerable, and I have frequently observed that waterfowl populations and production are low under these circumstances.

In Alberta this danger has recently grown, as small impoundments, previously lacking fish, are now being stocked with trout. Thomas (1958) described suitable waters as follows: "[they] vary in area from two to 200 acres . . . . Lakes of less than 200 surface acres are favored as concentrated fishing pressure, necessary for a good harvest, is more easily attained and losses are less when winter kills occur. . . . Maximum depths vary from 10 to 50 feet and in preferred cases no permanent inlet or outlet navigable to fish is present." It seems advisable, therefore, to keep depths under 15 ft. where impoundments are being developed expressly for waterfowl breeding areas. Unless water supplies are uncertain, as in some projects depending wholly on runoff, there is no particular advantage in having deep impoundments. Indeed, important food plants are primarily situated in the 0-4 ft. depth range. Should topography, etc. force construction of deep impoundments, it might be possible to secure a guarantee from provincial authorities beforehand that fish would not be stocked there.

Cattail Control--A grazing pressure of 1.2 head of cattle per acre per month, July to November, prevented the development of cattail along accessible shorelines on my study area. Fencing resulted in dense cattail stands which spread out to water depths of 3 ft. Preliminary trials with herbicides demonstrated that waterfowl usage of potholes can be greatly increased if shoreline cattail is reduced. Established cattail growth will not likely be eliminated from fenced areas by the resumption of grazing alone. Grazing together with herbicides probably offers the best means of permanent eradication. Effective chemicals and dates of application have been outlined by Martin et al., (1957). Mowing and drowning are two additional approaches to cattail control that may be applicable on some impoundments.

Impoundment Size--I feel that a mosaic of impoundments of varying size is definitely desirable in breeding-ground projects. The larger impoundments, e.g. D-area Lake, attract prenesting populations, and are best suited for water-level manipulations designed to increase the availability of spring food. Low damp terrain, frequently associated with pothole areas, promotes dense stands of Juncus nesting cover which need not be protected by fencing. These areas are preferred by breeding birds, while broods tend to move onto the larger potholes and lakes. The most satisfactory distribution and combination of such impoundments, ecologically, have yet to be determined.

Summary

A water-level manipulation to increase the quantity and availability of food in spring is suggested as a means of attracting larger breeding populations onto permanent impoundments. Measures to decrease skunk predation would likely increase nesting success. Intensive poisoning and trapping may be effective in controlling skunks on limited areas, but widespread usage of such practices is not feasible. Fenced areas are unsatisfactory, as their heavy cover concentrates both skunks and duck nests. Fencing also leads to establishment of trees which attract crows and magpies. Construction of small nesting islands is strongly recommended as an efficient method of rendering duck nests inaccessible to skunks. Probably little can be done to reduce duckling mortality appreciably, although elimination of extensive mudflat conditions lessens brood vulnerability to mammalian predators. Impoundments created for breeding waterfowl should not be deep enough to support a game-fish population. A combination of grazing and herbicide treatment will likely eradicate the dense cattail shorelines on fenced potholes, and increase their use by waterfowl. A mosaic of different sizes of impoundments is thought to constitute the most desirable kind of project.

APPENDIX

Common and Scientific Names of Birds and Mammals Mentioned in Text

The scientific names of birds are taken from the A.O.U. Check-list (1957); the scientific names of mammals are from Miller and Kellogg (1955).

Ducks and Geese

Common Names	Scientific Names
Baldpate (American Widgeon)	Mareca americana
Black Duck	Anas rubripes
Blue-winged Teal	Anas discors
Bufflehead	Bucephala albeola
Canada Goose	Branta canadensis
Canvasback	Aythya valisineria
Gadwall	Anas strepera
Green-winged Teal	Anas carolinensis
Mallard	Anas platyrhynchos
Old-squaw (Oldsquaw)	Clangula hyemalis
Pintail	Anas acuta
Redhead	Aythya americana
Ring-necked Duck	Aythya collaris
Ruddy Duck	Oxyura jamaicensis
Scaup (Lesser Scaup)	Aythya affinis
Shoveler	Spatula clypeata
Snow Goose	Chen hyperborea
White-winged Scoter	Melanitta deglandi

Other Birds

California Gull	Larus californicus
California Quail	Lophortyx californicus
Coot (American Coot)	Fulica americana
Crow (Common Crow)	Corvus brachyrhynchos
Duck Hawk (Peregrine Falcon)	Falco peregrinus
Eared Grebe	Podiceps caspicus
Magpie (Black-billed Magpie)	Pica pica
Marsh Hawk	Circus cyaneus
Pheasant (Ring-necked Pheasant)	Phasianus colchicus
Red-tailed Hawk	Buteo jamaicensis
Redwinged Blackbird	Agelaius phoeniceus
Ring-billed Gull	Larus delawarensis
Rough-legged Hawk	Buteo lagopus
Swainson's Hawk	Buteo swainsoni

Mammals

Badger	Taxidea taxus
Coyote	Canis latrans
Franklin Ground Squirrel	Citellus franklinii
Mink	Mustela vison
Muskrat	Ondatra zibethicus
Striped Skunk	Mephitis mephitis
Weasel (Long-tailed)	Mustela frenata

A List of the Plants Found on the Study Area

Scientific names were taken from Budd (1952) and from Fernald (1950).

CHARACEAE
- Chara sp.

EQUISETACEAE
- Equisetum prealtum

LYCOPODIACEAE
- Selaginella densa

TYPHACEAE
- Typha latifolia

ZOSTERACEAE
- Potamogeton filiformis
- Potamogeton friesii
- Potamogeton pectinatus
- Potamogeton pusillus
- Potamogeton richardsonii
- Potamogeton vaginatus
- Potamogeton zosteriformis
- Ruppia occidentalis
- Zannichellia palustris

JUNCAGINACEAE
- Triglochin maritima

ALISMACEAE
- Alisma gramineum

HYDROCHARITACEAE
- Anacharis canadensis

GRAMINEAE
- Agropyron dasystachyum
- Agropyron smithii
- Agropyron subsecundum
- Agropyron trachycaulum
- Agrostis scabra
- Agrostis stolonifera
- Alopecurus aequalis
- Beckmannia syzigachne
- Bouteloua gracilis
- Bromus inermis
- Calamagrostis inexpansa
- Calamagrostis montanensis
- Calamovilfa longifolia
- Deschampsia caespitosa
- Distichlis stricta
- Echinochloa crusgalli
- Elymus canadensis
- Hierochloë odorata
- Hordeum jubatum
- Koeleria cristata
- Muhlenbergia asperifolia
- Oryzopsis hymenoides
- Phleum pratense
- Poa arida
- Poa canbyi
- Poa palustris
- Poa pratensis
- Poa secunda
- Puccinellia nuttalliana
- Spartina gracilis

GRAMINEAE (cont'd.)

Sphenopholis obtusata
Sporobolus cryptandrus
Stipa comata
Stipa viridula

CYPERACEAE

Carex atherodes
Carex douglasii
Carex eleocharis
Carex heliophila
Carex lanuginosa
Carex praegracilis
Carex rostrata
Eleocharis acicularis
Eleocharis palustris
Scirpus americanus
Scirpus nevadensis
Scirpus paludosus
Scirpus validus

LEMNACEAE

Lemna minor

JUNCACEAE

Juncus balticus
Juncus nodosus
Juncus dudleyi

LILIACEAE

Allium textile
Zygadenus gramineus

IRIDACEAE

Sisyrinchium angustifolium

SALICACEAE

Populus tremuloides
Salix spp.

SANTALACEAE

Comandra pallida

POLYGONACEAE

Polygonum achoreum
Polygonum aviculare
Polygonum coccineum
Polygonum convolvulus
Polygonum lapathifolium
Polygonum natans

POLYGONACEAE (cont'd.)

Polygonum scabrum
Rumex crispus
Rumex maritimus
Rumex mexicanus
Rumex venosus

CHENOPODIACEAE

Atriplex argentea
Axyris amaranthoides
Chenopodium album
Chenopodium salinum
Salicornia rubra
Salsola pestifer
Suaeda depressa

AMARANTHACEAE

Amaranthus retroflexus

NYCTAGINACEAE

Oxybaphus hirsuta

CARYOPHYLLACEAE

Cerastium arvense
Spergularia salina
Stellaria longifolia

CERATOPHYLLACEAE

Ceratophyllum demersum

RANUNCULACEAE

Pulsatilla ludoviciana
Ranunculus cymbalaria
Ranunculus glaberrimus
Ranunculus sceleratus
Ranunculus subrigidus

CRUCIFERAE

Arabis holboellii
Capsella bursa-pastoris
Descurainia sophia
Erysimum parviflorum
Lepidium densiflorum
Lesquerella arenosa
Rorippa islandica
Thlaspi arvense

CAPPARIDACEAE

Cleome serrulata

ROSACEAE
Chamaerhodos nuttallii
Geum triflorum
Potentilla anserina
Potentilla arguta
Potentilla effusa
Potentilla pensylvanica
Rosa arkansana

LEGUMINOSAE
Astragalus caryocarpus
Astragalus goniatus
Astragalus pectinatus
Astragalus triphyllus
Glycyrrhiza lepidota
Hedysarum mackenzii
Lupinus pusillus
Medicago sativa
Melilotus alba
Melilotus officinalis
Oxytropis gracilis
Oxytropis macounii
Petalostemun purpureum
Thermopsis rhombifolia
Trifolium hybridum
Trifolium repens
Vicia trifida

LINACEAE
Linum rigidum

MALVACEAE
Malvastrum coccineum

VIOLACEAE
Viola adunca
Viola vallicola

CACTACEAE
Mamillaria vivipara
Opuntia sp.

ELAEAGNACEAE
Elaeagnus commutata

ONAGRACEAE
Epilobium adenocaulon
Epilobium angustifolium
Epilobium glandulosum
Epilobium lineare

ONAGRACEAE
Epilobium wyomingense
Gaura coccinea
Oenothera biennis
Oenothera nuttallii

HALORAGACEAE
Hippuris vulgaris
Myriophyllum exalbescens

PRIMULACEAE
Dodecatheon pauciflorum
Glaux maritima

CONVOLVULACEAE
Convolvulus arvensis

POLEMONIACEAE
Phlox hoodii

BORAGINACEAE
Cryptantha fendleri
Heliotropium curassavicum
Lappula redowskii
Lithospermum angustifolium
Oreocarya glomerata

LABIATAE
Lycopus asper
Mentha arvensis

SOLANACEAE
Solanum triflorum

SCROPHULARIACEAE
Orthocarpus luteus
Penstemon gracilis
Penstemon procerus

OROBANCHACEAE
Orobanche fasciculata

PLANTAGINACEAE
Plantago eriopoda
Plantago major

CAPRIFOLIACEAE
Symphoricarpos occidentalis

CAMPANULACEAE

Campanula rotundifolia

COMPOSITAE

Achillea lanulosa
Antennaria microphylla
Artemisia frigida
Artemisia gnaphalodes
Artemisia pabularis
Aster ericoides
Bidens glaucescens
Brachyactis angustus
Chrysopsis villosa
Cirsium arvense
Cirsium undulatum
Crepis tectorum
Erigeron canadensis

COMPOSITAE (cont'd.)

Erigeron philadelphicus
Grindelia perennis
Gutierrezia diversifolia
Helianthus annuus
Iva xanthifolia
Lactuca pulchella
Liatris punctata
Lygodesmia juncea
Ratibida columnifera
Rudbeckia hirta
Senecio columbianus
Senecio cymbalaroides
Senecio palustris
Taraxacum officinale
Tragopogon dubius

Methods of Sampling and Analysis

Sampling Terrestrial Vegetation

1. Mixed-Prairie Community: Two sampling methods were used on the mixed-prairie community. The first, carried out in 1956, consisted of 6 groups of 10 1-ft.-square quadrats on representative mesic sites (total—60 quadrats). The position of the first quadrat in each group was determined by throwing a stake forward, and placing the lower left corner of the quadrat on the point touched by the stake's nearest end. The remaining 9 quadrats were at 10-pace intervals from the first, and on an east-west line through it. Species present in each quadrat were listed.

The second method, employed in 1953 and 1954, involved establishing permanent marker-stakes in typical mesic stands. A 1-yd.-square frame subdivided into 1-ft.-square quadrats was used. There were 4 possible positions for the yd.-square frame around every marker-stake, and 9 1-ft.-square quadrat positions within each. Numbers from 1 to 4, and from 1 to 9 were drawn at random to determine which quadrat would be examined. None was examined twice. All vegetation in this quadrat was clipped off at ground level; the various species were separated, the number of stems counted, and their average height estimated. From such data, the total length of vegetation per quadrat was computed. In 1953, 4 marker-stakes were set out and quadrats taken at the end of July and August; 2 additional stakes were established in 1954, and quadrats taken at the end of May, June, July, and August (total--32 quadrats).

I believe the above methods were adequate to describe the mixed-prairie community on the study area; Rice (1952) concluded: "Characteristic species of the tall grass prairie community were delineated fairly well on the basis of either 20 or 40 0.1 square meter quadrats."

2. Juncus Community: The Juncus community was investigated much like the mixed prairie community. However, the differences were: (1) 4 groups of 5 quadrats, instead of 6 groups of 10, (2) quadrats in a line paralleling the shore of the nearest impoundment, rather than in a fixed east-west direction, and (3) no new marker stakes added in 1954 to the 4 initially established in 1953.

3. Halophytic Communities: Quadrats were taken in these communities during 1955, exactly as in the Juncus community.

Sampling Aquatic Vegetation

Transects across impoundments were made by boat in order to examine submergents in water 1.5 ft. and deeper. Sampling was conducted with a 10-ft. pole, bearing a 2-in. steel hook and graduated every 6 in. for depth readings. By pushing this pole to the bottom and revolving it several times in a circle roughly 18 in. in diameter, submergent vegetation was entangled and could be drawn to the surface. Preliminary trials in clear water, 2-3 ft. deep, indicated that this technique was satisfactory. Previous workers have used a variety of means, including diving outfits, weighted quadrat frames, and long-handled rakes, to sample aquatics (Ricket, 1921; Denniston, 1921; Swindale and Curtis, 1957). The length of the boat was used to gauge distance between stops along transect lines. In lakes, the average spacing was 3 to 5 boat-lengths (30-50 ft.), while in potholes it was 1 or 2.

Vegetation along the 1-ft. contour of Cy-, Cz-, and D-area Lakes was studied with yd.-square quadrats. A starting point was first selected randomly along the shoreline. From this, one walked directly into the water, and placed the quadrat at a depth of 1 ft. Since shoreline lengths were known, it was possible to estimate the distance between quadrats needed to produce a particular number of samples after one complete circuit.

Where submergent growth in sprayed <u>vs</u>. unsprayed cattail stands was investigated, a similar procedure was followed. In this instance, 10 quadrats were taken in the sprayed and unsprayed cattail, in each of 3 potholes.

<u>Sampling of Nesting Cover</u>

To determine the effect of grazing and to evaluate the potential species composition and concealment value of nesting cover, permanently marked transects were established in 1955, within and adjacent to two fenced areas--A-area and another, 1 mi. south. The second fenced area was utilized because it had been burned-over the previous spring, and I wished to appraise the effect of this burning on nesting cover 1 year later.

Transects were grouped in pairs, one member of each pair being situated about 15 ft. inside, and the other 15 ft. outside the fence. In both fenced areas, two pairs of transects were placed in mixed-prairie community; and in A-area, two pairs were also placed in the Juncus community. Transects were 100 paces long.

Ten 1-ft.-square quadrats were taken along each transect early in May, June and July 1955. Quadrat positions were determined by first drawing a number between 1 and 10; this indicated the number of paces from the end of the transect that the first quadrat would be positioned. The remaining 9 quadrats were taken at 10-pace intervals from the first. A taut cord fastened to the transect marker-stakes served to align quadrats. These steps were repeated in A-area's mixed-prairie transects during 1956, except that the number of quadrats per transect was doubled by reducing the interval to 5 paces.

Quadrats were also examined in typical mixed-prairie nesting cover elsewhere on the study area. Although these were taken at the same time as the quadrats along paired transect lines, the procedure was somewhat different, being similar to that outlined earlier for species-composition analysis of the mixed-prairie community in 1956. A total of 120 such quadrats were examined during 1955, and 180 during 1956. Because the Juncus community was comparatively uniform in density, I felt that additional quadrats here were not needed.

Vegetation in all quadrats was evaluated as to its potential nest-concealment rating (very good, good, fair, and poor), and the species constituting the primary nesting cover was recorded. Potential nest-concealment ratings were later converted to mean percentage light penetration values, just as was done for cover at actual nest sites.

Soil Analysis

Soil samples were collected at depths of 2-6 in. Samples from the same plant community were mixed together, air dried, labeled, and set aside for laboratory analysis at the Soils Department, University of Alberta. Here, using standard techniques (U.S. Salinity Lab. Staff, 1949), tests were made to determine pH, total soluble salts and relative amounts of various ions.

Water Analysis

Clean 4-oz. bottles were used to store water samples taken on the study area. Analyses were made at the University of Alberta, Edmonton, and at the Provincial Salinity Laboratory, Vauxhall.

Steps in Analysis of Stomach Contents

1. Preserved stomach contents were emptied into a 250-ml. beaker and sufficient water added to half fill it. This was next stirred vigorously with a glass rod so that much of the organic material was in suspension. The suspension was then carefully decanted into a funnel containing a cone of filter paper. After several decantations only the grit and a few of the heavier seeds remained in the beaker. These seeds were extracted with forceps and placed with the rest of the organic material trapped on the filter paper. The grit was then dried in the beaker over a low flame.

2. Seeds were separated from other organic material by washing the contents of the filter paper into a petri dish with sufficient water to almost fill it. This mixture was stirred lightly, and as the seeds usually remained at the bottom, the fine organic

material, leaves, soft-bodied insects, etc. were easily decanted into another dish or drawn off with a pipette. It was often necessary to complete the final stages of this sorting with forceps.

3. The seeds, still in the petri dish but with the excess water removed, were next segregated into various species or genera, counted, and their numbers recorded. Segregation and counting was greatly facilitated by a low-power dissecting microscope, a clean sheet of white paper beneath the dish providing desired contrast. A scalpel was useful for moving these seeds about. After indentification and counting, seeds were dried and stored in a small numbered envelope.

4. The bulk of nonseed organic material usually consisted of finely ground unidentifiable material. When recognizable plant parts--stems, leaves, etc.--were present, these were listed, as was the occurrence of invertebrates. Since animal remains constituted only a small percentage of the total food intake, I did not attempt to separate them from other nonseed fractions, but simply estimated their volume. This material, like the grit and seeds previously, was then dried over a low flame.

5. The final step in analysis was a volumetric measurement of total grit and nonseed organic material. A 10-ml. graduated cylinder was satisfactory for this task, the displacement of water being estimated to the nearest 0.02 ml. After measurement, the grit and the nonseed organic material were redried and stored in envelopes bearing the same number as that containing the seeds. Seed volumes were determined indirectly by multiplying numbers of seeds with a

conversion factor. Conversion factors were ascertained for seeds of each species by measuring the volume of a known number (100 to 1,000 depending on size).

Assumptions Made in Calculating Renesting Rates

The computation of over-all renesting rates for five species of ducks was based on breeding-pair estimates, nesting-study hatching success and numbers of nests found. The validity of these calculations rests on several fundamental assumptions:

1. Counts of adult ducks on study-area impoundments gave an accurate indication of the number of breeding pairs present. The manner in which adult-duck counts were made has been outlined earlier. As Sowls (1955:54-57) pointed out, such counts can be greatly affected by movements of pairs between water areas. However, the impoundments of the study area constituted a fairly distinct unit; and potholes and small lakes comprising about 91 percent of the total water surface and about 72 percent of the total shoreline were censused in a 2½-hr. period. I think, therefore, that relatively few birds were either duplicated or deleted during these counts.

2. Hen mortality over the nesting season did not appreciably affect renesting calculations. Losses of females on the study area during May to mid-July apparently averaged about 8 percent, as reported above in the present paper. I do not know whether females killed at nest sites (about 3 percent) were on first nests or renests, and one can only speculate on the nesting histories of other females that were found dead. Hence, appraisals of the effect of hen mortality

on renesting calculations are difficult. The chief potential source of error lies with the second group of hens, more specifically with those that died before attempting to nest. Such birds, however, likely represented a relatively small fraction of the total mortality, and losses of females probably did not—in my opinion—affect calculated renesting rates to any great extent.

3. Nests found on the study area belonged to pairs counted there, and any tendency for others to nest was counterbalanced by the opposite tendency among resident pairs, i.e. during the nesting season, emigration and immigration were equal in magnitude. While some pairs utilizing potholes immediately south of the study area may have been attracted to the dense nesting cover in A-area, I doubt that this frequently occurred. Vegetation on both sites consisted mainly of *Juncus* community, which provided good nesting cover irrespective of grazing.

4. The same proportion of nests was found for each of the five species shown in Table 52. I have no reason to believe that this assumption was not correct.

5. Hatching success recorded in the nesting study was representative of that occurring on the study area. Inasmuch as a high percentage of the nests on the study area was found (see below), and since it is thought that the activities of the investigators had little effect on predation rates, there seems little doubt that nesting-study hatching success was representative.

6. Hatching success of renests was the same as of first

nests. Although renests were not differentiated in the field, there was no significant difference between percentage hatch in early and late nests of any one species.

7. Nests overlooked in the nesting study, and breeding pairs on uncensused study-area waters, were two largely compensating errors. This final assumption is the most difficult to assess. One must first estimate the percentage of nests located. In three other investigations where dogs were used for nest hunting, and where coverage appeared to be thorough, the percentage of nests known to have been found was: 75 percent (Bennett, 1938b:122), 65-70 percent (Glover, 1956) and 75 percent (Steel et al., 1956). As a reasonable estimate, then, probably around 70 percent of the nests were located in the current study.

Numbers of pairs on water areas not included in regular counts were based upon numbers per unit of shoreline on comparable impoundments during 1953-57. Accordingly, 229 breeding pairs (exclusive of pintails) were estimated to have utilized uncensused ponds, giving a grand total of 891 pairs (229 + 662) on the entire study area. Since counted pairs represented approximately 74 percent of the total pairs present, and about 70 percent of all nests were presumably found, I believe that these two sources of error were compensating.

Changes In and Around Study-Area Impoundments, 1953-57

Major changes in vegetation, salinity, water levels, etc. involving impoundments of the study area's five subdivisions are summarized in Tables A to E and in Figs. A to E.

TABLE A.--SUMMARY OF MAJOR CHANGES IN AND AROUND Cz-AREA LAKE, 1953-57

Year	Emergent Vegetation	Salinity and pH of Water	Shoreline Vegetation	Salinity of Shoreline Soil	Shore-line Length (yd.)	Nesting Cover Around Lake	Levels of Natural Potholes Nearby
1953	Cattail--two new stands about 200 ft. by 50 ft., 2-2.5 ft. high in August	Est. at about 1000 p.p.m.	Very dense vegetation encroaching on mudflats--Hordeum jubatum, Eleocharis acicularis, Ranunculus cymbalaris, R. sceleratus, Chenopodium salinum; old-shoreline vegetation mostly dense stands of Hordeum jubatum and Juncus balticus	0.5% to >1.0% salts	1,200	Good	Most holding water throughout spring and summer
1954	Cattail--none Softstem Bulrush--some scattered clumps present by mid-July	Est. at about 250 p.p.m.	Dense flooded stand of Hordeum jubatum in May; marked increase in Juncus balticus during June-August	much less than 1953	1,200	Good	More potholes between Cz and A-areas
1955, 1956, and 1957	None	1955 and 1956 at about 1957 level of 250 p.p.m. pH 9.6	Mainly Juncus balticus; some encroachment of vegetation on limited mudflats	same as 1954	1,200	Good in 1955; Fair in 1956 and 1957	Potholes between Cz and A-areas same as 1954; rest same as around other areas 1955-1957

TABLE B.—SUMMARY OF MAJOR CHANGES IN AND AROUND Cy-AREA LAKE, 1953-57

Year	Emergent Vegetation	Salinity and pH of Water	Shoreline Vegetation	Salinity and pH of Shoreline Soil	Shore-line Length (yd.)	Nesting Cover Around Lake	Levels of Natural Potholes Nearby
1953 and 1954	None	Est. >1000 p.p.m.	Old shoreline largely *Hordeum jubatum* and *Juncus balticus*; growth on mudflats—*Hordeum jubatum*, *Eleocharis acicularis*, *Ranunculus cymbalaria*, *R. sceleratus* *Chenopodium salinum*	0.5% to >1.0% salts	2,900	Fair in 1953; Poor in 1954, 2/3 of cover destroyed in April fire	Most holding water throughout spring and summer
1955	None	Probably somewhat less than in 1953 and 1954	Edge of water at old shoreline in May with marked increase in *Juncus balticus*; mudflat vegetation flooded during May, some new growth June-August; marked increase in *Eleocharis palustris*	Probably somewhat less than in 1953 and 1954	3,600	Fair	Most dry or very low by early June
1956	Good stand of Alkali Bulrush on and around island	1043 p.p.m. salts, pH 9.2	Shoreline and mudflat vegetation similar to 1955	Same as 1955	3,600	Fair	Dry by end of May
1957	Heavy stand of Alkali Bulrush on and around island	800 p.p.m. salts, pH 9.5	Shoreline and mudflat vegetation similar to 1955	Same as 1955	3,600	Fair	Dry throughout spring and summer

TABLE C.—SUMMARY OF MAJOR CHANGES IN AND AROUND D-AREA LAKE, 1953-57

Year	Emergent Vegetation	Salinity and pH of Water	Shoreline Vegetation	Salinity and pH of Shoreline Soil	Shore-line Length (yd.)	Nesting Cover Around Lake	Levels of Natural Potholes Nearby
1953 and 1954	Cattail--restricted to five island borders Softstem Bulrush--in center of lake; no old growth standing; new growth badly thinned by muskrats	Est. at about 200 p.p.m.	Mainly Juncus balticus, Carex praegracilis, and Lycopus asper	Negligible salts, pH 8.1	3,600	Good	Most holding water throughout spring and summer
1955	Cattail--new stand on mud-flat island by end of July Softstem Bulrush--dense stand of new growth by end of June, with muskrats being controlled; when control measures stopped, stand largely destroyed by mid-July	Same as 1953 and 1954	Main shoreline vegetation same as in 1953 and 1954; growth on mudflats by end of June--Cattail (6 in. high), Eleocharis acicularis, Ranunculus cymbalaria, Hordeum jubatum--this growth heavily trampled and grazed during July-August	Probably some increase	3,900	Same as 1953 and 1954	Most dry or very low by early July
1956	Cattail--permanently established on site of mud-flat island in 1955 Softstem Bulrush--same as 1953 and 1954	200 p.p.m. salts, pH 7.5	Increasing amount of Hordeum jubatum appearing along shoreline	0.7% salts, pH 8.0	3,600	Fair--effect of less rain and grazing	Dry by end of May
1957	Cattail--same as 1956 Softstem Bulrush--previous year's growth visible; new growth dense, muskrat numbers low	186 p.p.m. salts, pH 9.5	Further increase in Hordeum jubatum	1.0% salts, pH 7.7	3,600	Same as 1956	Dry throughout spring and summer

TABLE D.—SUMMARY OF MAJOR CHANGES IN AND AROUND B-AREA POTHOLES, 1953–57

Year	Emergent Vegetation	Salinity of Water	Shoreline Vegetation	Salinity of Shoreline Soil	Shoreline Length (yd.)	Nesting Cover Around Potholes	Levels of Natural Potholes Nearby
1953 to 1957	None	Great variation between potholes, probably similar to salinities recorded in 1957, viz. 288, 500 and 2285 p.p.m. in three potholes	Mainly Juncus balticus and Carex praegracilis, also very good stands of Eleocharis palustris and Scirpus americanus; halophytes along some shorelines on patches of saline mudflat	Great variation, from well over 1.0% salts to negligible	2,200	Good	Same condition as around D-area Lake

TABLE E.—SUMMARY OF MAJOR CHANGES IN AND AROUND A-AREA POTHOLES, 1953–57

Year	Emergent Vegetation	Salinity and pH of Water	Shoreline Vegetation	Salinity of Shoreline Soil	Shore-line Length (yd.)	Nesting Cover Around Potholes	Levels of Natural Potholes Nearby
1953	<u>Cattail</u>--present in every <u>pothole</u>, totals about 5 ac. in water <u>Softstem</u> <u>Bulrush</u>—a few <u>scattered</u> <u>clumps</u> that have been planted	Est. at about 200 p.p.m.	5150 yd. of Cattail; 750 yd. of mainly <u>Juncus</u> <u>balticus</u>, and <u>Carex</u> <u>praegracilis</u>; good growth of <u>Eleocharis</u> in some potholes	Great variation, >1.0% in small patches, mostly negligible	5,900	Very Good	Most holding water throughout spring and summer
1954	<u>Cattail</u>—stands in com<u>pletely</u> flattened condition in spring due to severe grazing and trampling in late fall 1953; new growth 2 ft. high by May 20, no loss of stand density <u>Softstem</u> <u>Bulrush</u>--same condition as <u>Cattail</u>	Same as 1953 —	Both Cattail and <u>Juncus</u>-<u>Carex</u> shorelines <u>complete</u>-<u>ly</u> <u>flattened</u> in spring due to severe grazing and trampling in late fall 1953; new Cattail growth 2 ft. high by May 20; good recovery of <u>Juncus</u> <u>balticus</u> by end of first week of June	Same as 1953	5,900	Poor in May; Fair to Good in June; Very Good in July	More potholes present between A and Cz-areas
1955	<u>Cattail</u>--spreading; herb<u>icide</u> sprayed on about 1/2 ac. in mid-August <u>Softstem</u> <u>Bulrush</u>—same as <u>1953</u>	Same as 1953	Much like 1953; <u>Eleocharis</u> <u>palustris</u> being <u>crowded out</u> <u>by Cattail</u>; herbicide sprayed on 750 yd. of cattail shoreline in mid-Aug.	Same as 1953	5,900	Very Good	Most dry or very low by early June; potholes between A- and Cz-areas same as 1954

Table continued on next page

(cont'd.)

1956	Cattail--spreading; herbicide treatment made little difference to density of old growth standing in early May; marked difference by end of May as old growth falling over and little new growth appearing on sprayed sites Softstem Bulrush--same as 1953	Av. 270 p.p.m. pH 6.7	See notes on Cattail under "Emergent Vegetation"; Juncus-Carex same condition as in 1953; further reduction in Eleocharis palustris	Same as 1953	5,900	Very Good	All dry by end of May except potholes between A and Cz-areas
1957	Cattail--spreading, now totals about 10 ac. in water; marked difference in density between sprayed and unsprayed stands of old growth during early May; new growth on sprayed and unsprayed sites about equal, little difference noticeable by early June Softstem Bulrush--same as 1953	Av. 196 p.p.m. pH 8.8	See note on Cattail under "Emergent Vegetation"; Juncus-Carex same condition as in 1953; most Eleocharis palustris now gone	Same as 1953	5,900	Good in May; Very Good in June and July	All dry throughout spring and summer except the ones between A and Cz-areas

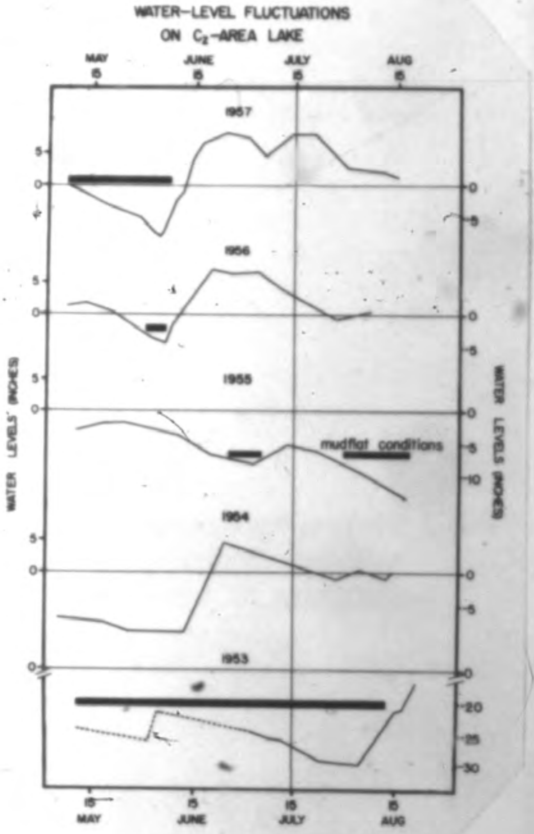

Fig. A.

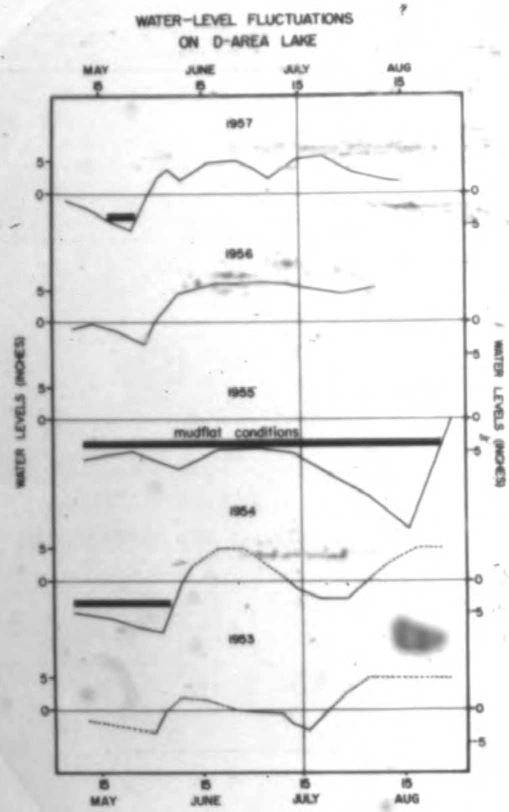

Fig. C.

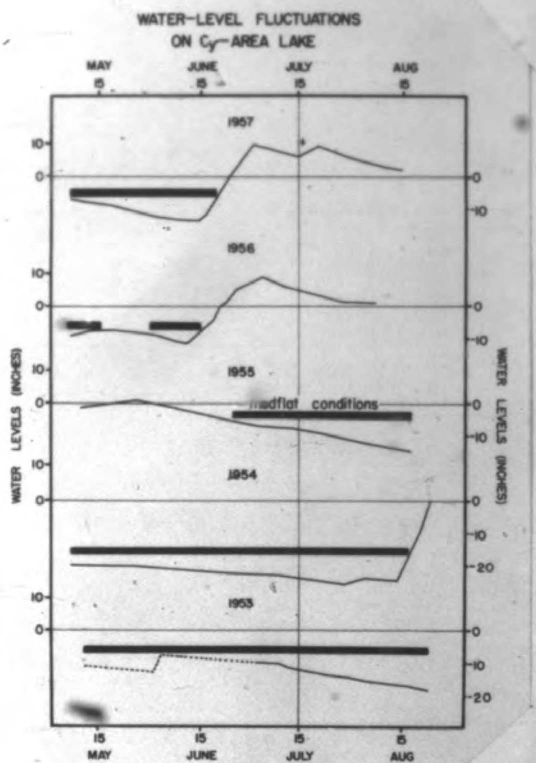

Fig. B.

Figs. A, B and C. Water-level fluctuations and mudflat conditions on the three lakes of the study area. Depth was estimated where dotted line is shown.

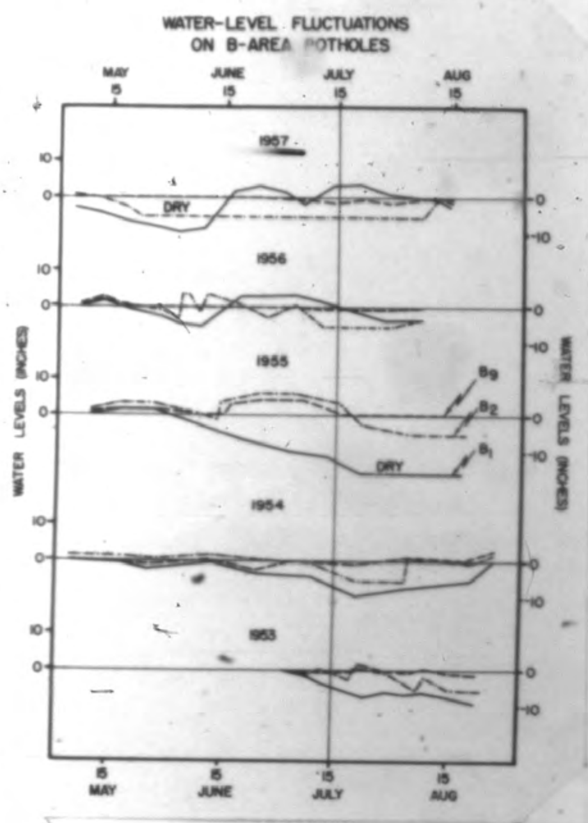

Fig. D.

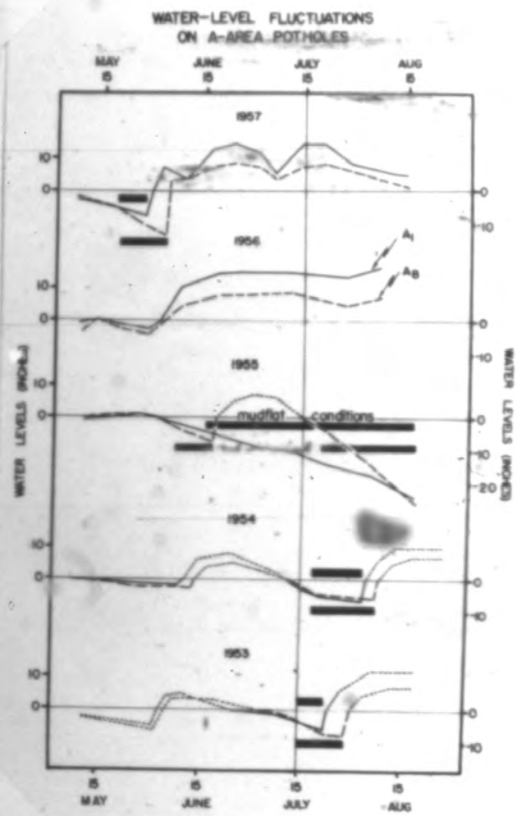

Fig. E.

Figs. D and E. Water-level fluctuations on two groups of potholes on the study area; mudflat conditions are not shown for B-area Potholes, but were present continuously on portions of B_1, B_2, and B_9.

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TITLE OF THESIS A STUDY OF WATERFOWL ECOLOGY ON SMALL IMPOUNDMENTS IN SOUTHEASTERN ALBERTA

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Publications See attached list.

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